ANHYDROUS AMMONIA NITROGEN [illegible]
GRAIN SORGHUM, AND BAHIAGRASS SOD IN
MULTIPLE CROPPING MINIMUM TILLAGE SYSTEMS

BY

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ANHYDROUS AMMONIA NITROGEN FOR TROPICAL CORN, GRAIN SORGHUM, AND BAHIAGRASS SOD IN MULTIPLE CROPPING MINIMUM TILLAGE SYSTEMS

By

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Nitrogen is the largest and one of the most expensive fertilizer components used in growing corn (Zea mays L.), sorghum (Sorghum bicolor L. Moench), and bahiagrass (Paspalum notatum Flugge) in the United States.

The first study investigated the effect of anhydrous ammonia N on the yield and chemical composition of tropical corn and grain sorghum when planted by no-tillage management into bahiagrass sod. The experiments were conducted at three locations and arranged in randomized complete block designs with six replications at five N rates (0, 56, 112, 168, and 224 kg N ha^{-1}). A second study was conducted to determine the effect of rates (as stated above) and sources of N on the yield and chemical composition of bahiagrass forage. Nitrogen rates were whole plots and sources of N (anhydrous ammonia vs. ammonium nitrate) were split plots replicated four times.

[illegible] grain ammoni[illegible] accumulation and nutri[illegible] grain sorghum, and forage sor[illegible]

Tropical cor[illegible] $^{-1}$ at locations 1 and 3 and [illegible] The corn grain to residue ratio, over [illegible] 280% over the control due to inc[illegible] and whole plant DM yields increas[illegible] locations which was probably due to insu[illegible] to ear fill period

Grain sorghum DM yiel[illegible] to 56 kg N ha^{-1} at two locations [illegible] increased to 112 kg N ha^{-1} at location three [illegible] distribution of rainfall affected corn [illegible] yields

When anhydrous ammonia was compared to [illegible] nitrate as sources of N for bahiagrass, no differences in DM yiel[illegible] found. Nitrogen, in vitro organic matter digestibility (IVOMD), and [illegible] concentrations increased with increased rates of N and were greater when ammonium nitrate was used as the source of N The concentration of all nutrients studied responded to all rates of N.

Dry matter accumulation and nutrient content of tropical grain sorghum, and forage sorghum increased rapidly following early vegetative growth Nitrogen, P, K, Ca, Mg, Fe, Mn, Cu, and Zn concentrations increased rapidly during early vegetative growth and decreased rapidly thereafter.

CHAPTER I
LITERATURE REVIEW

Introduction

[illegible] southeastern United States [illegible] could be more fully utilized if [illegible] multicropping [illegible] systems were feasible. Also, there are more than 16 million acres of Entisol and Ultisol soil types which make up a major portion of the ridge throughout south, central, and north Florida. These soils produce different growth habits in corn, sorghum, and forage growth which needs to be researched. Florida is a grain deficient state and utilization of existing sods for interplanting grains would allow more efficient utilization of capital, time, labor, and resources. Producers throughout the state are currently facing depressed prices for field crops and livestock, which makes the need for sound management decisions and best utilization of resources a necessity to continue in the risky business called "farming". Costs for establishing bahiagrass (*Paspalum notatum* L. Flugge) sod have increased as have costs for producing other commodities. The value of this forage crop in rotations with other crops is well established, and the ability to interplant corn (*Zea mays* L.) or grain sorghum (*Sorghum bicolor* L. Moench) into this sod while maintaining the sod for fall regrowth would be desirable. Throughout most of Florida, bahiagrass is the predominant improved forage for grazing by cattle. This pasture [illegible] summer [illegible] can be [illegible] proper applic[illegible] fertilizer. However, with low beef prices and increased cost [illegible] fertilizer, much of this pasture is never fertilized adequately for good forage quality and productivity. [illegible] anhydrous ammonia (AA), one of the least expensive sources of N [illegible] fertilizer material might lend itself to use in interplant cropping systems in sod or for use as the main source of N for bahiagrass pasture fertilization.

No-Tillage Multicropping Corn and Sorghums in Sods

No-tillage and other forms of minimum tillage have gained popularity rapidly during the past decade, especially in the midwestern and southeastern United States. Compared to conventional tillage systems, no-tillage and other types of minimum tillage can offer several advantages, including increased soil moisture availability (Blevins et al., 1971, Gallaher, 1977), reduced soil erosion loss (Langdale and Leonard, 1982), less planting delays, and fuel savings (Robertson and Prine, 1978). In addition, no-tillage practices allow growers to utilize crop residues and mulches more effectively for soil improvement and crop protection. Probably the major contributing factors to yield response from the use of mulch are increased water infiltration and reduced losses from water runoff (Langdale and Leonard, 1982). By covering the exposed soil surface, mulches reduce water loss from evaporation as well as reduce erosion losses due to wind and water. Mulches may also be used as a soil amendment by increasing water soil [illegible] exchange site [illegible] nutrient [illegible]. Many [illegible] farmers are incr[illegible] chances for success by utilizing no-tillage or no-tillage plus [illegible]ing to plant one or more crops in their multicropping system (Gallaher, 1980). Multicropping no-tillage farming requires a high level of management that most producers have not experienced (Gallaher, 1980). No-tillage has numerous advantages over conventional tillage planting management. No-tillage reduces erosion (Moldenhauer and Amemiya, 1969). No-tillage conserves soil moisture when plantings are into a chemically controlled mulch crop and indications are that a more vigorous root system develops to aid in withstanding drought stress (Gallaher, 1977). Moisture availability to plant roots throughout the growing season is one of the most critical factors limiting crop yield. Crop water stress is influenced by the total water available to the plant, stage of growth of the plant, and the rate of evapotranspiration. The magnitude of crop yield reduction is directly dependent upon the duration and severity of water stress.

According to Gallaher (1978), mulch tillage is one system used to help conserve soil moisture and includes leaving residues from previous crops or utilizing chemically suppressed sods on the soil surface in which to plant crops by no-tillage or other minimum tillage methods (Adams et al., 1973, 1970; Bennett et al., 1976; Blevins et al., 1971, Fink and Wesley, 1974, Griffith et al., 1973, Jones et al., 1969, Moschler et al., 1973, Shear and Moschler, 1969). Properly utilized mulch can result in significant increases in yields of corn (Blevins et al., 1971, Gallaher, 1977, Jones et al., 1969; Moody et al., 1963, Shanholtz and Lillard, 1969). Mulch material also reduces loss of

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1963 [illegible]
corn [illegible]
removal [illegible] 1000 kg ha^{-1} [illegible] in yield [illegible] better util[illegible] moisture [illegible] attribut[illegible] higher yields [illegible] mulch (Gallah[illegible] Nelson [illegible] b) in no-tillage [illegible] corn or grain sorghum following wheat (Triticum aestivum L.) [illegible] (Hordeum vulgare L.) found that no-tillage corn and grain so[illegible] higher yields when early planted (after small grain for [illegible]) than when planted late (after small grain for grain). Small [illegible] observed for irrigated early-planted no-tillage corn and grain sorghum were attributed to a higher soil water content [illegible] irrigated no till[illegible] crops. Gerik and Morrison (1984) found no differences in yield between no-tillage and conventional planted grain sorghum following wheat, and there were trends toward better soil water content under the no-tillage throughout sorghum development each year of the study. A Virginia study showed that mulched treatments, whether of undisturbed killed orchardgrass (Dactylis glomerata L.) sod on no-tillage plots or of wheat straw on conventional plots, gave the lowest water runoff and highest soil water content and yield of corn (Jones et al., 1969). Another Virginia study showed a 1460 kg ha^{-1} yield increase of corn from no-tillage in orchardgrass and versus conventional tillage. This was attributed to less water runoff, less evaporation, and negligible erosion (Shanholtz and Lillard, 1969). Elkins et al. (1979) no-tillage planted corn into tall fescue (Festuca arundinacea Schreb.) and found that it was possible to obtain good corn yields while maintaining at

[illegible]

[illegible]

[illegible] (1980) [illegible] published in Florida on minimum tillage of crops [illegible] 1974, Prine 1967; Robertson et al., 1966, [illegible] and [illegible] 1968; Robertson et al., 1976). None of these studies [illegible] of no-tillage in row subsoil planting. Three studies [illegible] red utilizing in row subsoiling when corn or sorghum [illegible] planted into bahiagrass sod but none of these studies [illegible] ammonia as a source of N (Gallaher 1978; Robertson [illegible] Hanley and Gallaher 1980). Gallaher (1978) reported [illegible] sorghum tended to yield about the same for no tillage versus [illegible] tillage in a bahiagrass sod. Bahiagrass was effectively [illegible] preapplication of glyphosate (isopropylamine salt of [illegible]-(phosphonomethyl) glycine) (Roundup) and post direct application of paraquat (1,1'-Dimethyl-4,4'-bipyridinium ion) in this study. Robertson et al. (1980), using subsoil planting into bahiagrass sod, found there was a large response to subsoiling for both the no-tillage and conventional method of tillage, but a greater response with no-tillage. The yield responses, over tillage methods, for subsoiling were related to stand. Stands (plants ha^{-1}) were improved by subsoiling but more so for no-tillage than conventional. Forage yields correlated with grain yields but bahiagrass regrowth yields at harvest were better when corn yields were low. This suggests that the better groundcover of the higher yielding treatments shaded out undergrowth. For the 3 years of the experiments, grain yields for no-tillage were superior or as good as the conventional method when narrow rows were used and the soil was [illegible] [illegible] n into bahia[illegible] [illegible] yields of up to 9400 kg ha^{-1} [illegible] with [illegible] practices on bahiagrass sods, however [illegible] plots were under limited irrigation management.

Nitrogen Fertilization [illegible]d Sorghum

The rapidly increasing cost of [illegible] tion is forcing an interest in practices that reduce or limit the specific cost variables normally associated with crop production. Some practices which have been shown to be beneficial in reducing production costs are reduced tillage, double cropping, and crop rotations. Other methods used to cut production costs include reductions in fertilizer usage, plant populations, and herbicide usage. Excessive reduction in any of these and similar essential items may reduce crop yield below an economical level and actually increase rather than decrease production costs (Touchton, 1980). Anhydrous ammonia is one of the cheapest sources of N which could be used in no-tillage multicropping systems for corn and grain sorghum.

Nitrogen fertility is an important factor in obtaining maximum yields of corn or sorghum (Anderson et al., 1985). The response of corn to increased N fertility differs considerably. Some experimental hybrids show increases in protein content and/or grain yield as rates increase (Kamprath et al., 1973, Warren et al., 1980, Nelson, 1956). Anderson et al. (1985) reported that prolific (more than one ear per plant) genotypes maintained a greater N utilization efficiency than the semiprolific genotypes at all N fertility levels and showed a greater

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The ge[illegible]
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study to determ[illegible] response of grai[illegible] to applied
Lutrick (1978) [illegible] that in general the [illegible] sorghum and
corn did not in[illegible] significantly whe[illegible] N ha^{-1} was
applied on a yearly basis. The protein [illegible] increased in the
grain of sorghum and corn for increment[illegible] including 11[illegible]
kg N ha^{-1}. Perry and Olson (1975), stud[illegible] of N fertilization on yield and quality of corn and [illegible] residues, observed that
grain N concentration increased with N [illegible] in both crops.
Grain sorghum N concentration was generally [illegible] to or greater than
corn. Residue yields of both crops were increased significantly by
90 kg N ha^{-1} with no further increase at the higher N rate. Corn grain/stover ratios increased with increasing N levels. Crude protein of grain sorghum residues was consistently higher than corn while in vitro organic matter digestibility (IVOMD) values were consistently lower in grain sorghum. Crude protein increased significantly in grain sorghum residue with each increasing N level while little increase occurred in corn. Perry and Olson (1975) observed that corn dry matter (DM) yields declined as much as 30% within 100 days of harvest. Any decline in crude protein and digestibility following grain harvest of corn and grain sorghum appears to be associated with environmental factors.

Touchton (1980) and Touchton and Hargrove (1982) stated that some of the cheaper N fertilizers are more susceptible to losses through ammonia volatilization than the more expensive ones. These losses are [illegible] Climatic [illegible] ammonia volatilization [illegible] occur in any particular [illegible] are difficult to predict. Mengel et al. (1982) found that injecting [illegible] or urea ammonium nitrate (UAN) below the surface resulted in significantly higher corn grain yields than applying UAN, NH_4NO_3 or urea directly on the soil residue surface. Nitrogen concentration in the [illegible] and grain also reflected an increase in N use efficiency with subsurface N placement. Percent N in leaf was significantly higher where NH_3 or UAN were injected as compared to UAN or urea surface applied. Eckert (1981) stated that research has shown little if any difference in corn yield as a result of using different N sources in conventional tillage production systems. However, the same was not true for no-tillage systems due to crop residues which may intercept much material and hold it above the soil surface until rain fall washes it into the profile. Prolonged contact with crop residues may cause loss of applied N and reduce yields. The extent of N loss will be affected by the type of N fertilizer, the application method used, soil surface pH, soil drainage, climate, and the nature of the crop residue. Eckert (1981) reported that anhydrous ammonia is the preferred source of N in no-tillage systems. Since this material is injected into the soil, it does not interact with surface residue and no problems associated with tillage or residue are normally encountered. Subsurface N application has less effect on surface pH, making it easier to maintain a favorable pH for weed control.

Smith (1964) stated that the effect of rate of N application can be quite variable, depending on the crop under consideration

[illegible]

[illegible] f ammonia application acc[illegible] [illegible] [illegible]reciably [illegible] and grain protein content, although yield was not substantially increased. Colliver and Welch (1970) conducted experiments to study the effect of preplant anhydrous ammonia on germination and early growth of corn. Corn was planted directly over and parallel to NH_3 bands applied at different rates, depths, and times before planting. Injurious effects on corn observed with certain NH_3 treatments were reduced stand, stunted early growth, restricted seedling root development, and increased occurrence of P deficiency symptoms. Increasing depth of application was more effective at reducing injury than was increasing the time interval between application and planting. Injury was largely prevented when application depth was 25 cm. for all times and rates of application. Mills et al. (1974) reported that toxicity may be partially overcome if the soil pH is near neutrality. The principal factors affecting NH_4^+ losses from soil are soil reaction and the amount of NH_4^+ N applied, but depth of fertilizer placement, cation exchange capacity (CEC), base saturation, and soil moisture content also affect retention and volatilization of NH_4^+ (Mills et al., 1974). Gomez and Loynachan (1984) stated that the nitrification of ammonium to nitrate is a stepwise biological oxidation in which NH_4^+ ions are converted to nitrite (NO_3), mainly by the bacteria of the genus Nitrosomonas, and NO_2 is further oxidized to NO_3 by Nitrobacter. The end product of nitrification (NO_3) is not strongly attached to the soil's cation exchange sites and, thus, is subject to leaching losses by percolating water. Fenn and Kissel (1976) reported that an increasing [illegible] $^{+}$ [illegible] d NH_4^+ [illegible] iveness of soil [illegible] Boswell (1977) stated that th[illegible] anhydrous ammonia is reported to be equ[illegible] in some studies, and superior to the [illegible] some conditions. Various workers reco[illegible] that differ[illegible] as well as application depth, play a maj[illegible] in pre[illegible] sorption. In addition, moisture conte[illegible] tilth, pH, dist[illegible] influenced by applicator spacings, and temperature, have [illegible] influence the availability of N from anhydrous ammonia.

Nitrogen Fertilization of Bahiagrass

There are 5 million acres of improved bahiagrass pasture in the southeastern United States. This pasture grass is easily maintained and provides beef cattle producers with an acceptable forage for cattle to graze during late spring, summer, and early fall. The yield and quality of bahiagrass can be improved by proper application of N fertilizer (Beaty et al., 1960, 1977; Blue, 1966, 1972, 1974; Stanley et al., 1977). However, with low beef prices and increased cost for N fertilizer, much of this pasture is never fertilized adequately for good forage quality and productivity.

Nitrogen is the largest and one of the most expensive components of bahiagrass fertilization. While anhydrous ammonia is one of the least expensive sources of available N, research in the 1930's conducted by Blue and Eno (1954) and Blue (1964) indicated that a loss of up to 40% of applied N could occur due to volatilization of ammonia.

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[illegible] ing of [illegible]
Since the 1950's, [illegible] point [illegible] may make the utilization of [illegible] ammonia [illegible] economical [illegible] other sources of N. The cost of N from ammonium nitrate (34% N) is [illegible] times that of anhydrous ammonia (82% N). Many studies have been conducted concerning the use of various N rates and sources for fertilization of bahiagrass and other tropical forages (Beaty et al., 1960, [illegible], 1977, 1980; Blue, 1972, 1974, 1977). Follett and Wilkinson (1985) reported that effectiveness of N sources varies with placement, soil and environmental conditions. Ammonium nitrate often has the highest recovery efficiency. Losses of NH_4^+ can occur from surface-applied urea, resulting in a lower efficiency of N use. Anhydrous ammonia fertilizers are usually the lowest priced per unit of N and have low loss rates if properly injected into the soil (Follett and Wilkinson, 1985).

Nitrogen is the main limiting nutrient in many forage systems; as a consequence, large yield increases are obtainable with N fertilization (Dougherty and Rhykerd, 1985). When N is applied to grasses, the higher crop growth rates achieved are most often attributable to increased leaf area indices (LAI). Nitrogen-fertilized grasses have larger cells with thinner cell walls and, as a consequence, have larger leaves. Nitrogen also stimulates meristematic activity, which is often reflected in increased tillering. Leaf senescence is also retarded by N fertilization which helps to maintain the photosynthetically active surface (Dougherty and Rhykerd, 1985).

[illegible] reported that f[illegible] kg DM per[illegible] kg^{-1} N applied) [illegible] ha^{-1} t[illegible] for the additional [illegible] 168 kg N ha^{-1} and further to 5 [illegible] from 168 to 336 kg N [illegible]. They stated that with unfertilized bahiagrass, N should be [illegible] before early March, but after the first year, time of [illegible]ation makes no practical difference in yield. At low N r[illegible], [illegible]ting to a stubble height of 3 cm or less will significantly [illegible] the amount of forage utilized and harvested. It was concluded that close grazing or clipping of 'Pensacola' bahiagrass (1) increases digestibility by keeping the forage green (2) increases the effective yield of a pasture, and (3) may provide better forage distribution over a season without affecting yield when split applications of N are made. Most bahiagrass forage is produced by vegetative tillers which terminate in stolons and bear their meristems, including the leaf growing points, at the soil surface. Leaf production is continuous during the summer (Beaty et al., 1977) and the stolons may be utilized as a feedstuff for beef cattle (Rodriquez et al., 1973). Some tillers develop flowering culms which account for a substantial portion of the July to August growth, but for only a small amount of the total season's forage. Forage production of 'Pensacola' bahiagrass as affected by N rates at a clipping height of 6 to 7 cm has been established and subsequent studies by Stanley et al. (1977) using clipping heights from 0 to 15 cm showed forage yields were negatively related to height of clipping.

Tropical grasses have been reported to grow better than temperate grasses at low N levels. One reason may be that temperate grasses have [illegible] (Ball-able t[illegible] Hoveland, [illegible]). Another reason may be that tropical grasses [illegible] N concentrations partly because of higher proportions of stem and sheath tissue (Mott, 1974).

Usually 50-80% of N applied to forage grasses is recovered in the harvested DM (Lazenby, 1983). Recovery may exceed 100% if fertilizer N increases the availability of soil N. Recovery is dependent on rate and time of application, source of N, soil N availability, species, temperature, moisture, and the interval between application and harvest (Dougherty and Rhykerd, 1985).

Limited information is available on the response of bahiagrass to anhydrous ammonia as a fertilizer source of N. The efficiency of using anhydrous ammonia in comparison to other sources of N on various crops has been studied by many investigators (Smith, 1966). Tucker and Crowe (1966) summarized the results of many investigations testing the effectiveness of various sources of N on several crops in comparison to anhydrous ammonia. They concluded that anhydrous ammonia was equal to most other N sources. The results of most experiments on forage indicate that, during the year of application, yields are somewhat higher from grasses fertilized with ammonium nitrate in split applications than with anhydrous ammonia applied in one application at rates of 112 to 324 kg N ha^{-1} (Tesar, 1974). Burton and Jackson (1962) conducted trials on 'Coastal' bermudagrass (Cynodon dactylon L.) for 5 years utilizing anhydrous ammonia as one source of N. The anhydrous ammonia was applied in 40 cm rows with a chisel-type knife. Total yields were greater for ammonia nitrate fertilized grass at the 112 and 224 kg rates of N when fertilizer was applied in split applications.

[illegible] ammonia was equal [illegible] (1968) found [illegible] rates of N application [illegible] ammonia produced lower [illegible] in the first clipping and [illegible] yields in succeeding clippings. This lag in response was attributed to sod burn from escaping ammonia. Reducing the application spacing tended to increase NH_3 retention, decrease sod burn and [illegible] the NH_3 efficiency at the high rates of N application. Newer [illegible] effective application equipment may be the cause of the [illegible] application efficiency. Lechtenberg et al. (1974), using [illegible] ammonia to fertilize smooth bromegrass (Bromus inermis Leyss.) found that it was as effective in increasing animal production per hectare as was ammonium nitrate at the same application rate.

Increasing the N fertilizer for tropical forages has been shown to increase DM yield and crude protein content. However, more diverse information is available on the effect of N rate and environmental factors on the digestibility of tropical grasses. Moore et al. (1970) reported that 'Pensacola' bahiagrass hays at varying maturities differed in crude protein content from 10.5 to 7.6% after 2, 4, and 6 weeks of growth and from 7.0 to 5.2% after 10 or more weeks of growth. In vitro organic matter digestibility (IVOMD) varied from 63.0 to 60.7% after 2, 4, or 6 weeks of growth and from 53.3 to 46.0% after 10 or more weeks growth. They concluded that 'Pensacola' bahiagrass has a potentially good quality in terms of voluntary intake and nutrient digestibility. However, quality did decline quite rapidly between 6 and 10 weeks of growth. Low crude protein content may be the primary [illegible] be the primary limiting [illegible] quality). Van Soest (1985) also reported that [illegible] nutritive quality with age. He stated that age and physiological maturity are not identical. Thus, factors such as cool temperature and light that retard maturity promote higher quality at a given age.

Most date-of-cutting studies represent first cuttings taken during the spring and early summer, when the effects of the warming season and maturity positively interact. Such studies show steep declines in digestibility and protein and increases in fiber, lignin, and other cell wall components. Date-of-cutting information is less useful in evaluating second cuttings or aftermaths grown in July through September. At this time, environmental temperature is maximum and no longer increasing, and digestibilities are not as high in immature material as they were in the spring. As temperatures decline in the fall, nutritive value may actually increase with the age of the plant (Van Soest, 1982). The tropical environment differs in that there is generally a much higher solar intensity, which, in combination with adequate moisture and high temperature, means extremely rapid plant development and growth toward maturity.

Van Soest (1985) stated that crude protein content as influenced by fertilizer N is the most important effect of fertilization. He also stated that digestibility is affected relatively little, although palatability may be. Wilson (1973) indicated that increasing the N supply from low to moderate levels increased digestibility by 3-5% and caused a small increase in total soluble carbohydrates in panicgrass (Panicum maximum var. trichoglume). Many investigators (Button et al., [illegible] concentrations and [illegible] increasing levels of N fertilizer. [illegible] digestibility has not been demonstrated as frequently. [illegible] reviewed 22 papers where high and low levels of N had been used on a number of species, including bermudagrass, and concluded that a 1% increase in digestibility was due, on the average, to higher rates of N. Fribourg et al. (1971), using 'Midland' bermudagrass, found the average digestible DM increase to be from about 37 to 46% over the range of applied N. The greatest increase occurred as the N rate was increased from 133 to 400 kg N ha^{-1}.

Henderson and Robinson (1982a) stated that in the southeastern United States the climate during the growing season of summer perennial grasses is characterized by considerable fluctuations in temperature, solar radiation, and rainfall. These climatic fluctuations have been associated with seasonal variations in yield and forage quality of the warm-season grasses (Henderson and Robinson, 1982a). Growth rates of most tropical grasses increase with temperature to 30 to 35 C and increase with light intensity to 60,000 lux or higher. Conditions favoring maximum growth rates have frequently resulted in reduced forage quality. High temperatures during growth periods have been related to increased proportions of stem, increased fiber concentrations, decreased water-soluble carbohydrate concentration, and reduced herbage digestibility of tropical grasses (Henderson and Robinson, 1982a, Wilson and Ford, 1973, Wilson and Minson, 1980, Wilson et al., 1976). Henderson and Robinson (1982b), in a study of tropical grasses including 'Pensacola' bahiagrass, found that in all grasses that IVOMD [illegible] decreased as temperature increased, resulting in maximum digestibility at the lowest temperature. The effect of light on digestibility ranged from positive to negative, depending on the grass and temperature. Maximum digestibilities occurred at the high soil moisture level after 14 days regrowth. The digestibility of the 'Pensacola' bahiagrass was 3.6 percentage units higher after 14 days regrowth than after 21 days regrowth.

Dry Matter Accumulation and Mineral Composition of Corn and Sorghum

Increase in dry weight is a useful definition of growth for those interested in crop productivity. Knowledge of DM production and of nutrient uptake and distribution is needed to relate to plant growth and development (Jacques et al., 1975). Crop growth is usually more accurately characterized by measurement of dry weight than measurement of fresh weight, which can be strongly influenced by prevailing moisture conditions.

Dry weight increase has been described mathematically as a function of physiological, phenological, and environmental factors. Increase in dry weight with time is usually characterized by a sigmoidal curve (Leopold and Kriedemann, 1975), in which three primary phases are recognized: expansion, linear, and senescence (Richards, 1969). In the expansion phase, the growth rate (increase in dry weight per unit of time) is initially slow but the rate increases continuously as more dry weight is added. Accumulation of dry weight is exponential until self-shading or other conditions prevent the increasing leaf area from producing a proportionate increase in the weight of the plant.

[illegible], 19[illegible]; Leopold and Kriedemann, 1975; [illegible]). The [illegible] expansion phase [illegible] the beginning of the linear phase in which the increase in DM continues at a constant rate. The final, senescence phase is characterized by a decrease in growth rate as the crop approaches maturity and begins to senesce (Salisbury and Ross, 1978).

The patterns of growth and DM distribution observed in tropical maize (Goldsworthy and Colegrove, 1974) suggest that the capacity of grain sink to accommodate assimilate can limit grain production. McPherson and Boyer (1977) pointed out that another potentially serious problem occurs if sink size has been affected by low leaf water potential. Moss (1962) and Allison and Watson (1966) have shown that when grain sink is limited, DM that would have passed to the grain, accumulates in the stem and husk. Anderson et al. (1985) indicated that source-sink relationships are important in the accumulation and distribution of N and DM. They found that prolific genotypes of corn maintained a greater N utilization efficiency than the semi-prolific genotypes at all N fertility levels and showed a greater decrease in N utilization efficiency as N fertilization was increased. The prolific genotypes partitioned a larger proportion of plant N to the grain at all N fertility levels, apparently by increasing N remobilization. The semi-prolific genotypes responded to increased N fertility by increasing the ear number per plant, grain N content, and grain yield.

Some investigators have measured the inorganic nutrient uptake by corn and sorghum. It has been recognized that amounts of most nutrients removed by a crop harvested for silage may be much more than when the same crop is harvested for grain (Hanway, 1966).

[illegible] climatic [illegible] genotype, and fertilizer [illegible] content of each element (Fribourg, 1974). [illegible] by Owen and [illegible] showed little difference in the mineral nutrient content of corn and sorghum, except for K, which can be influenced by fertilization.

Fribourg et al. (1976) reported the results of inorganic nutrient uptake by corn and sorghums. The amounts removed in the above-ground plant parts exhibited considerable range: 34 to 222 kg N ha^{-1}, 8 to 34 kg P ha^{-1}, 31 to 271 kg K ha^{-1}, 8 to 55 kg Ca ha^{-1}, and 9 to 45 kg Mg ha^{-1}. Since the quantities removed are the products of harvested plant part weights and percent composition, they are influenced not only by the climatic, edaphic, genotypic, and management considerations, but also by soil nutrient availability. Sivakumar et al. (1979) suggested that plant growth is the result of an effective integration of many factors. Restriction of growth may occur due to the limitation of any one factor. For example, water deficits in plants generally lead to reduced leaf water potentials and stomatal closure, as manifested by an increased leaf resistance to transpiration. The effects of depletion and replenishment of soil water on transpiration are of specific importance to water use and its efficiency in crop production. The relative rates of absorption and transpiration determine a plant's internal water balance, which directly affects the physiological and biochemical process of plant growth. It is widely accepted that corn grain yields are most severely reduced by water stresses which occur during the silking and tasseling stages of growth. Additional water stresses which occur later during the grain filling period can further

[illegible]
Vegetative growt [illegible] sorghum growth which [illegible] (Bennett 1984, Denmead and Shaw, 1960, Eck, [illegible] [illegible], 1978, Sinclair et al., 1975)

Growth and DM production of grain sorghum have been reported by several workers. Vanderlip and Reeves (1972), who defined 10 growth stages of grain sorghum from emergence to physiological maturity, suggested that by using these stages as standards the timing of sampling or treating of sorghum could be described accurately in relation to the morphological or physiological age or status of the plant. They report that the general pattern of DM accumulation was the same for different grain sorghum hybrids and that late maturing hybrids tended to have higher DM at each stage of development than did earlier maturing hybrids

Jacques et al. (1974), in studies of grain sorghum hybrids, found that Ca and Mg uptake was rapid in early plant development, and Ca was generally taken up more rapidly than Mg during vegetative growth When vegetative growth had been completed, more than half of the plant's total Ca and Mg uptake had occurred. Whole plant nutrient concentrations decreased through most of plant growth due to dilution. Zinc and Cu concentrations did not decrease as much during grain development as during vegetative growth Lockman (1972b), reported that soil acidity, soil fertility, stage of growth, variety, and climatic conditions affected the mineral composition of grain sorghums. Jacques et al. (1975) found that 20 to 30 days after emergence sorghum plants began to grow rapidly, their dry weight increased faster than uptake of [illegible], thus [illegible]. Hanway (1962a) found that differences in soil fertility [illegible] the amounts of N, P, and K taken up by corn plants, but did not markedly change the seasonal pattern of uptake and distribution of these elements in the plants. The accumulation of N, P, and K in corn and grain sorghum was linear in relation to DM accumulation (Fribourg et al., 1976, Hanway, 1962b).

Corn and grain sorghum production may be greatly enhanced by proper fertilization. As fertilization efficiency is highly interactive with many soil properties and climatic factors, plant analysis has been used as a measurement of the soil-plant nutrient environment. Since nutrient availability as measured by soil testing may or may not be highly correlated to final crop yields, plant analysis can be used effectively in conjunction with soil tests to examine both critical levels of nutrients needed by the crop and the ability of the soil to supply those amounts. Both of these analyses are necessary to determine nutrient cycling in multicropping systems and to refine the fertilizer requirements of a particular system.

Abundant literature exists concerning plant analysis data for corn although few data are available for grain sorghum. Because of this imbalance and the observations of early researchers that the two crops contain similar amounts of most elements, they have often been discussed together. Lockman (1972a, b) and Bennett (1971), however, warn that although nutrient concentrations in the crops are similar, differences increase in later growth stages and corn data should not be used to evaluate growth sorghum.

Since nutrient elements are not evenly distributed throughout a plant and fluctuate widely during its growth, it is of great importance [illegible] generally recommended that, for diagnostic sampling, [illegible] collecting 15 to 25 ear leaf samples from [illegible] and grain sorghum be sampled by collecting 15 to 25 samples [illegible] second leaf from the top of the plant at heading (Jones and [illegible]). Whole plant sampling at physiological maturity is not a good [illegible] nutrient sufficiency in a plant but may be used to determine [illegible] plant content to be used in nutrient cycling determinations

Critical nutrient levels (CNL) have been the object of [illegible] controversy and may be defined in several ways (Tyner, 1946, [illegible] 1952) but are essentially the concentration of an element below [illegible] yields decrease or deficiency symptoms appear Because of the [illegible] interactions among nutrient elements themselves (Fork et al [illegible] other confounding influences such as soil types (Gallaher and Jellu[illegible] 1976) and cultivar differences (Lutz et al., 1972), CNL values must [illegible] used with care Tables 1-1 and 1-2 list ranges of CNL's for corn [illegible] grain sorghum Values are for the ear leaf at silk for corn and the third leaf below the panicle at bloom for grain sorghum Lockman (1972c) further reported that N and P levels in leaf tissue were both well correlated with sorghum grain yield but that K levels were more irregular and not as well correlated Zinc levels exhibited a curvilinear correlation with grain yield, the correlation becoming negative as yields increased above the 6280 kg ha^{-1} In corn, yields and nutrient concentrations in the leaf may be also highly correlated Bennett et al (1973) noted grain yield increases with increasing N and P levels in the ear leaf

Table [illegible]. Critical values for nutrient sufficiency ranges [illegible]

Element	Critical values for corn ear leaf	Nutrient sufficiency ranges Corn ear leaf	 [illegible] leaf	[illegible]	[illegible]
		[illegible]			
N	3.00	2.76–3.50	3.30–[illegible]	[illegible]	[illegible]
P	0.25	0.25–0.40	0.20[illegible]	[illegible]	[illegible]
K	1.90	1.71–2.50	1.40–1[illegible]	[illegible]	[illegible]
Ca	0.40	0.21–1.00	0.3–[illegible]	[illegible]	[illegible]
Mg	0.25	0.22–0.60	[illegible]	[illegible]	[illegible]
		[illegible]			
Mn	15	20–150	8–190	[illegible]	[illegible]
Fe	15	21–250	65–100	[illegible]	[illegible]
Zn	15	20– 70	15– 30	[illegible]	[illegible]
B	15	20– 70	15– 30	[illegible]	—
Cu	5	6– 20	2– 7	[illegible]	[illegible]
Al	---	200	0–220	[illegible]	[illegible]

SOURCES: Critical values for corn ear leaf, Jones [illegible]
Nutrient sufficiency range, Lockman (197[illegible]c).
Corn grain at maturity, Jones (1967).
Sorghum grain at maturity, determined by Agronomy [illegible] Analytical Research Laboratory of the Soil Science Department, [illegible] Florida, R. N. Gallaher (personal communication, 1983).

Table [illegible]

[illegible]	[illegible]	[illegible]	[illegible]ciency Range
Potassium (K	[illegible]	[illegible]	[illegible]
Calcium (Ca	[illegible]	[illegible]	[illegible]
Magnesi[illegible]	[illegible]	[illegible]	[illegible]
Sulf[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

CHAPTER [illegible]

ANHYDROUS AMMONIA AS A SOURCE OF NITROGEN FOR TROPICAL CORN PLANTED INTO BAHIAGRASS SOD BY MINIMUM TILLAGE [illegible]

Introduction

Nitrogen fertilizer is used in large amounts and is the most expensive input used in growing corn (*Zea mays* L.) in the [illegible]. Most areas of the Southeast are occupied by perennial sods and could be more fully utilized if interplant multicropping, minimum tillage systems were feasible. Multicropping systems utilizing bahiagrass (*Paspalum notatum* L. Flugge) and followed by temperate [illegible] have been studied (Gallaher, 1978, Lundy et al., 1974, Prine, 1967, Prine and Robertson, 1968, Robertson et al., 1976, 1980, Stanley and Gallaher, 1980). However, only a few of those studies involved in-row subsoiling and none utilized anhydrous ammonia as the sole source of N. As mentioned, several researchers have investigated reduced or no-tillage corn production and have shown it to be advantageous over conventional tillage on land subject to erosion hazards. Robertson et al. (1976) have cited several factors that contribute to the acceptance of no-tillage crop production. Highly erosive land can often be utilized for no-tillage grain production without serious soil losses. Elkins et al. (1979) showed that planting into sod usually involves the use of a contact herbicide to chemically kill or suppress the grass sod. They found in their experiments that it was possible to obtain good corn [illegible] This method [illegible] and grazing of [illegible]

Some red[illegible] tillage management for cropping sys[illegible] layer of crop residues on the soil surface that can result in [illegible] soil water content and reduced soil temperatures during the [illegible] which has led to increased N losses through leaching and denitrification (Thomas et al , 1973, Unger, 1978) The [illegible] loss through leaching and denitrification has been attributed to [illegible] increased soil water content and an increased number of large [illegible] contiguous to the soil surface (Thomas et al , 1973)

Opportunities to incorporate N fertilizers below the re[illegible] in reduced tillage systems are limited Consequently, the most [illegible] methods currently used in no-tillage systems are broadcasting of solid ammonium nitrate (NH_4NO_3) or urea or spraying urea-ammonium nitrate (UAN) solutions on the soil surface immediately before or after planting However, significant N losses can occur through ammonia volatilization when ammonium N sources, particularly urea, are left on the soil surface and exposed to the atmosphere (Bandel et al , 1980, Ernst and Massey, 1960, Hargrove et al., 1977, Terman, 1979, Volk, 1959) A number of soil and environmental factors affect the amount of N lost through ammonia volatilization from surface-applied N fertilizers Among these are soil pH, cation exchange capacity (CEC), soil organic matter (OM) content, amount and type of residue present, soil moisture content, temperature, humidity, and the N source used (Fenn and Kissel, 1976, Ernst and Massey, 1960, Terman, 1979) Because of the large number of interacting factors involved, the actual amount

to NH_3 [illegible]
[illegible] 1981 [illegible]

In addition to N losses from [illegible], a significant portion of the N applied in no-tillage [illegible] immobilized in the decaying residue mulch and [illegible] amount of N available to the growing crop ([illegible]). [illegible] anhydrous ammonia could be the preferred [illegible] systems. [illegible] this material is injected into [illegible] interact with surface residue and no problems [illegible] residue are normally anticipated. Subsurface [illegible] effect on surface pH, making it easier to obtain [illegible] weed control (Eckert, 1981). Mengel et al. (1982) [illegible] injecting NH_3 or UAN below the surface resulted in consistently [illegible] yields than applying UAN, NH_4NO_3, or urea directly on the soil-residue surface.

Corn has potential for late season planting and production of a second crop to increase productivity in the Southeast (Chambliss et al., 1979, 1980, Gallaher and Horner, 1983, Mascagni et al., 1980, Widstrom and Young, 1980). These studies involved tropical corn hybrids. Mid- to late summer plantings of temperate hybrids developed for different planting dates and environments experienced numerous pest problems (All and Gallaher, 1976, 1977, Widstrom and Young, 1980, Young et al., 1978). No-tillage planting a summer crop such as tropical corn into a grass sod could help control erosion problems due to wind or water. Therefore, methods for chemically suppressing late spring and summer grass growth, but allowing for fall regrowth would be desirable. The renovation of the pasture sod with in-row subsoiling plus having grass regrowth and crop residues for livestock to graze in the Fall could

[illegible]

[illegible] anhydrous ammonia as the sole [illegible] tropical [illegible] into bahiagrass sod using [illegible] methods.

Materials and Methods

Field Procedures

The experiment was conducted at three locations during 1983 and 1984. The experiment was in a randomized complete block design with six replications (Table 2-1) utilizing Pioneer brand 'X304C' tropical corn planted into 15-year old bahiagrass (cv. 'Pensacola') sods. Location 1 was planted on June 1, 1983, on a Kershaw fine sand (thermic uncoated typic Quartzipsamment) an excessively drained sand and location 2 was planted on June 23, 1983, on a Chiefland fine sand (loamy, siliceous, thermic, Arenic Hapludalf). The third location was planted on May 29, 1984, on an Arredondo fine sand (loamy, siliceous, hyperthermic grossarenic Paleudult). Locations 1 and 3 were in Levy County, Florida, latitude 29°30' North, longitude 82°40' West. Location 2 was in Gilchrist County, Florida, latitude 29°50' North, longitude 82°40' West.

Ten days prior to planting, an application of 0.84 kg a.i. glyphosate ha^{-1} (isopropylamine salt of N-(phosphonomethyl) glycine) (Roundup) plus 1.9 L of X-77 surfactant of 95 L of water was applied in a spray volume of 26 L ha^{-1} at 2.8 kg cm^{-1}. This was done to suppress the bahiagrass sod prior to planting.

[illegible] analysis [illegible] randomized [illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
TREATMENTS [illegible]	[illegible]
ERROR	[illegible]

[illegible] ha^{-1} [illegible] ting [illegible] of K [illegible] sulfate of Potassium. The plots [illegible] 76 cm wide, and [illegible] length. The [illegible] were planted [illegible] subsoil planter with anhydrous tubes attached [illegible]. Corn was planted at a population [illegible] 62,000 pl[illegible]tion was provided at any location. [illegible] application [illegible] active ingredient (a.i.) Carbofuran ha^{-1} (2,3-Dihydro-[illegible]-benzofuranyl methylcarbamate) (15G Furadan) was applied in front of the press wheel at planting. Nitrogen was applied at planting under the row and injected on the subsoil sh[illegible] at a 25 cm depth. Nitrogen rates were randomized and replicated six times at 0, 56, 112, 168, and 224 kg N ha^{-1}.

On July 10 at location 3 and on July 26 and 27 at the other two locations, 0.05 kg a.i. paraquat ha^{-1} (1,1'-Dimethyl-4,4'bipyridinium ion) plus 0.5 L X-77 in 95 L of water was direct sprayed to further suppress the sod. The plots were harvested on the following dates at the three locations: September 12, 1983, September 26, 1983, and September 9, 1984. Two rows 6 m in length were hand harvested from each plot for yield determination. The samples were weighed and a five plant subsample taken for dry matter (DM) determination and chemical analyses. At 40 days post-emergence, five whole plants and five youngest mature leaves were collected from each plot for chemical analyses. At corn bloom, five ear leaves were collected from each plot for chemical analyses. Planting, plant sampling, and harvest dates are shown in Table 3-2.

Table 2-2 Planting and harvesting dates, and plant sampling dates for [illegible] corn when [illegible] tillage planted into bahiagrass sod.

Operation for Corn	1983		[illegible]
	[illegible]	[illegible]	[illegible]
		[illegible]	
1 Planting date	6/[illegible]	[illegible]	[illegible]
2 Youngest mature leaf	8[illegible]	[illegible]	
3 Whole plant	8/2	[illegible]	
4 Ear leaf at bloom for corn	8/26	8/20	
5 Harvest at black layer	9/26	[illegible]	[illegible]
6 Soil samples	[illegible]	[illegible]	[illegible]

[illegible]

for [illegible] weighed. Samples were prepared for further laboratory analysis by grinding in a Wiley mill [illegible] stainless steel screen and then stored in air-tight plastic bags.

Soil samples were taken during the experiment after corn harvest. Soil test results are shown in Appendix Table A-7.

Laboratory Procedures

For all soils, N analysis employed a micro-kjeldahl procedure (Bremner, 1965) as modified by Gallaher et al. (1976). A 2.0 g sample was placed in 25 ml digestion tubes to which 3.2 g of catalyst (90% anhydrous K_2SO_4, 10% anhydrous $CuSO_4$), 10 ml concentrated H_2SO_4 and 2 ml 30% H_2O_2 were added. Samples were then digested in an aluminum block digester (Gallaher et al., 1975) for 2.5 hours at 375 C. Upon cooling, solutions were diluted to 75 ml with deionized water. Nitrogen concentrations of these prepared solutions were determined using an AutoAnalyzer.

All soil P, K, Ca, Mg, Fe, Cu, Mn, and Zn analyses were conducted using procedures recommended by the University of Florida's Soil Testing Laboratory using a double acid extraction procedure (Mehlich, 1953). Five grams of air-dried soil were extracted with 0.05 N HCl + 0.025 N H_2SO_4 at a soil:solution ratio of 1 to 4 (W:V) for 5 minutes. Soil P was then analyzed using colorimetry. Potassium was determined by atomic emission spectrophotometry. Calcium, Mg, Fe, Cu, Mn, and Zn were determined by atomic absorption spectrophotometry. Soil pH was determined using a 2:1 water:soil ratio.

[illegible] procedure [illegible] placed in 75 ml [illegible] catalyst (90% anhydr[illegible] 10% anhydro[illegible] concentrated H_2SO_4 and 2 ml of [illegible] were added. [illegible] digested in an aluminum block digestor (Gallaher et al., [illegible]) [illegible] hours. Upon cooling, solutions [illegible] diluted to 75 ml [illegible] water. Nitrogen concentration [illegible] these solutions [illegible] Technicon II AutoAnalyzer.

Phosphorus, K, Ca, Mg, Fe, Cu, Mn and [illegible] were determined by a routine dry ashing mineral analysis procedure as modified by R. N. Gallaher (personal communication, Agronomy Department, University of Florida, Gainesville, FL, 1983) in which 1.0 g samples were placed in 50 ml pyrex beakers and ashed in a muffle furnace at 480 C for a minimum of 4 hours. After cooling, each was treated with 2 ml concentrated HCl and heated to dryness on a hot plate. An additional 2 ml of concentrated HCl + water was added to the dry beakers followed by reheating to boiling and then diluting to 100 ml volume with deionized water. Solutions were analyzed for P using colorimetry on an AutoAnalyzer. Potassium was determined by atomic emission spectrophotometry. Calcium, Mg, Fe, Cu, Mn, and Zn were determined by atomic absorption spectrophotometry. Organic matter was determined as the loss in weight after ashing the DM samples.

In vitro organic matter digestibility (IVOMD) of plant material was determined by the Tilley and Terry (1963) two-stage procedure adapted by Moore and Mott (1974, 1976) and expressed on an OM basis (Moore et al., 1972; Moore and Mott, 1974, 1976).

[illegible]

[illegible] least significant difference (LSD) [illegible] responses and regression analysis for orthogonal polynomials utilizing contrast statements where appropriate. The data from individual locations were analyzed separately due to an interaction between treatments and locations. Where ANOVA indicated differences (probability of F — 0.05) LSD's were employed to compare treatment means. In the cases where there was response to N fertilization rate, appropriate regression analysis was conducted. Regression terms were incorporated into the model if judged significant at the 0.05 level by the F test or if a higher order term in the same variable was judged significant.

The ANOVA, LSD, regression analyses, and correlations were performed at the Northeast Regional Data Center (University of Florida, Gainesville, FL) using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS). Data filing and transformations were performed on a Tandy Radio Shack TRS-80 Model III or IV (48K or 64K RAM microcomputer).

Results and Discussion

The success of dryland or non-irrigated crop production is dependent on precipitation during the crop growing season and available water stored in the soil. Rainfall data for the three experiments conducted during 1983-84 are found in Table 2-3. Droughty conditions were reflected in grain yields of corn with the most severe stress occurring during the silking and grain fill periods at location 1. When the data

TABLE [illegible] [illegible] [illegible]ring 198[illegible] [illegible] corn was planted [illegible]

[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	[illegible]
	mm		
[illegible]			
5/25			[illegible]
5/30			[illegible]
6/5			
6/10	[illegible]		
6/15			[illegible]
6/20	[illegible]		[illegible]
6/25	[illegible]	25	[illegible]
6/30	[illegible]		
7/5	[illegible]	84	[illegible]
7/10	[illegible]		
7/15			
7/20		102	
7/25	[illegible]	25	[illegible]
7/30	[illegible]		[illegible]
8/5	[illegible]		38
8/10			
8/15			18
8/20	[illegible]	127	51
8/25			
8/30			
9/5		[illegible]	10
9/10			

[illegible]

[illegible]).

[illegible] accumulation [illegible], residue, and whole plant DM [illegible] to 56 kg N ha^{-1} at locations 1 and 3 which was probably [illegible] rainfall during the silking to ear fill period [illegible] grain yield [illegible] with increasing rate of N at location [illegible] was [illegible]. This physiological response of [illegible] to drought stress has been reported previously by Shimshi (1969).

Corn grain yield increased at locations 1 and 3 in response to 56 kg N ha^{-1} and to 112 kg N ha^{-1} at location 2 (Table 2-4). Grain yields [illegible] the three locations ranged from 250 kg ha^{-1} at the zero [illegible] ha^{-1} at the 224 kg N ha^{-1} rate. The corn grain to residue ratio reacted differently to N rate at each location and increased to 56, 112, and 168 kg N ha^{-1} at locations 1, 2, and 3, respectively. Corn grain to residue ratio averaged over the three locations showed a 250% increase from 0 to 224 kg N ha^{-1}. Anderson et al. (1985) stated that the response of corn to increase N fertility differs considerably due to genotype, climatic, and other environmental conditions. Some hybrids show increases in protein content and/or grain yield as N rates increase (Kamprath et al., 1973; Nelson, 1956). Selke and Russell (1980) reported that some corn inbreds showed no response while others showed linear or quadratic yield responses to increased fertility.

Dry matter yield for corn residue and whole plant increased up to 168 kg N ha^{-1} at location 2 (Table 2-4). The number of ears ha^{-1} increased in response to 56 kg N ha^{-1} at locations 1 and 2, however,

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	Avera[illegible]
kg N ha^{-1}		[illegible] yield Mg DM ha^{-1}		
0	[illegible]	[illegible]	.26	[illegible]
56	[illegible]	[illegible]	1 76	1 [illegible]
112	[illegible]	[illegible]	2.24	2.00
168	[illegible]	[illegible].25	[illegible] 22	[illegible]
224	[illegible]	3 58	[illegible] 54	[illegible]
LSD 0.05	[illegible]	86	58	
		--- Residue Mg DM ha^{-1} ---		
0	[illegible]	1 12	1 18	1.32
56	[illegible]	[illegible] 97	2.82	2.40
112	[illegible]	3 79	3.30	3 17
168	[illegible]	[illegible].30	3.46	3.63
224	[illegible]	[illegible].31	4 23	3 73
LSD 0.05	[illegible]	.98	82	
		--- Whole plant Mg DM ha^{-1} ---		
0	1 79	1 35	1 54	1.56
56	3 79	4.45	4.58	4.27
112	3.80	5 97	5 74	5 17
168	4 25	7.54	5.69	5.83
224	3 32	7 88	6 77	5 99
LSD 0.05	1.02	1.57	1.23	
		--- Grain/residue ---		
0	.15	19	24	19
56	.45	.52	61	.53
112	.38	77	.64	60
168	.36	.82	.68	.62
224	.27	83	62	37
LSD 0.05	.15	.23	14	

[illegible] [illegible] number that [illegible] [illegible] rat[illegible] [illegible] The decrease [illegible] indicate a [illegible] physiological problem as well as more barren plants at this [illegible]

There were no differences in the number of plants ha^{-1} [illegible] tions 1 and 2, however, location 3 did show significant dif[illegible] varying rates of N The number of ears/stalk responded to [illegible] at all three locations

The shelling percent of corn grain was similar at locatio[illegible] 1 but was significantly lower at location 2 and responded to [illegible]

[illegible] st every plant process is affected directly or indir[illegible] water deficits. When plants are subjected to water stress there is a decrease in photosynthesis and cell enlargement There is also [illegible] siderable retention of carbohydrates in photosynthetic tissue Although translocation proceeds, its rate is reduced. It is generally accepted that optimized grain filling requires continued DM production and translocation of the product to the grain Hanway (1962a) reported that the potential yield of corn grain which is produced late in the season is determined by the leaf area, which is produced early in the season However, less than this potential yield of grain will actually be attained if (a) the net assimilation rate is decreased by any factor such as a moisture deficiency later in the season or (b) the leaf area is prematurely reduced by some factor that results in premature death of leaves such as a nutrient deficiency or insect, disease, or hail damage If no other factor limits yield, one would expect that

Table 2-5 Response of tropical [illegible] anhydrous ammonia

N Treatment	[illegible]			Average
	1	[illegible]	[illegible]	
kg N ha^{-1}	[illegible]			
0	44,470	[illegible]	[illegible]	38,440
56	39,450	[illegible]	[illegible]	39,840
112	39,450	[illegible]	[illegible]	41,360
168	37,660	[illegible]	[illegible]	39,810
224	39,450	[illegible]	30,130	41,600
LSD 0.05	NS*	[illegible]	4,650	
	Ears ha^{-1}			
0	13,630	27,970	16,140	18,290
56	30,840	40,890	25,460	32,100
112	29,050	45,900	29,770	34,900
168	28,690	50,930	24,750	35,200
224	25,100	51,290	32,280	36,340
LSD 0.05	9,750	9,540	5,530	
	Ears/stalk			
0	0.31	0.58	0.72	0.47
56	0.78	0.78	0.93	0.80
112	0.74	0.85	0.97	0.84
168	0.76	0.93	0.97	0.88
224	0.64	0.93	1.07	0.87
LSD 0.05	0.22	0.25	0.23	
	Shelling percent			
0	78	55	72	68
56	76	65	77	74
112	78	72	77	76
168	77	75	77	76
224	70	73	76	73
LSD 0.05	NS	5	NS	

*NS = Not significant at the 0.05 level of probability

[illegible]

[illegible]

Moss (1962) [illegible] the corn grain sink is missing, DM that would have been translocated to the grain accumulates in the stem and husk. Goldsworthy and Colegrave (1974) have shown that the presence of more barren plants probably explains why more dry weight accumulated in the stems of corn plants. Missing grain sink would also account for the differences in the values for grain yield during the current study, since barren plants contribute to DM but not to grain yield.

Jurgens et al. (1978) in a water stress experiment showed that as grain development progressed, the rate of grain fill began to exceed DM accumulation, indicating a net redistribution of stored assimilates. Eck (1984) stated that N fertilizer increases water-use efficiency of N deficient soils when water is adequate but less is known of the effects of high rates of N when water is limiting. Randel et al. (1975) demonstrated decreased DM yields of corn from N rates in excess of 200 kg N ha^{-1} at low water level treatments. Denmead and Shaw (1960) indicated that moisture stress prior to silking reduced grain yield by 25%, moisture stress at silking reduced grain yield by 50%, and stress after silking reduced grain yield by 21%.

Utilizing contrast statements for orthogonal polynomials, stalk DM yield showed a linear response to N rate at all three locations (Table 2-6). However, grain DM yield, whole plant DM yield, and the grain to stover ratio showed quadratic responses to N at location 1 but linear at locations 2 and 3.

[illegible]

[illegible]	[illegible]	
[illegible]		
[illegible] yield kg ha^{-1}	[illegible]	[illegible]
Stalk yield kg ha^{-1}	[illegible]	[illegible]
Whole plant yield kg ha^{-1}	[illegible] $-$ 378X^2	[illegible]
Grain/stover	[illegible] $-$ .05X^2	[illegible]
N conc grain dag kg^{-1}	[illegible]	[illegible]
N content grain kg ha^{-1}	[illegible] + .19X	[illegible]
N conc stalks dag kg^{-1}	[illegible] + .08X	[illegible]
N content stalks kg ha^{-1}	[illegible] + 3.5X	[illegible]
DOM grain kg ha^{-1}	[illegible] + 5.7X	[illegible]
IVOMD stalks dag kg^{-1}	[illegible] + 1.86X	[illegible]
DOM stalks kg ha^{-1}	[illegible] + 175X	[illegible]
Location 2		
Grain yield kg ha^{-1}	Y = −280 + 884X	[illegible]
Stalk yield kg ha^{-1}	Y = 882 + 771X	[illegible]
Whole plant yield kg ha^{-1}	Y = 592 + 1616X	[illegible]
Grain/stover	Y = 17 + 15X	[illegible]
N conc grain dag kg^{-1}	Y = 1.35 + .04X	[illegible]
N content grain kg ha^{-1}	Y = −5.2 + 12.7X	[illegible]
N conc stalks dag kg^{-1}		NS
N content stalks kg ha^{-1}	Y = 3.45 + 4.6X	0.62
IVOMD grain dag kg^{-1}		NS
DOM grain kg ha^{-1}	Y = 580 + 10.2X	0.40
IVOMD stalks dag kg^{-1}	Y = 53 − 8.5X + 1.2X^2	0.51
DOM stalks kg ha^{-1}	Y = 386 + 302X	0.59

Table [illegible] (continued)

Dependent Variable	[illegible]	r^2
Location 3		
Grain yield kg ha^{-1}	Y = 97 + 502X	0.55
Stalk yield kg ha^{-1}	Y = 1098 + 654X	0.48
Whole plant yield kg ha^{-1}	Y = 1396 + 1156X	0.55
Grain/stover	Y = .31 + .08X	0.35
N conc grain dag kg^{-1}	Y = .59 + .19X	0.76
N content grain kg ha^{-1}	Y = -2.7 + 8.6X	0.70
N conc stalks dag kg^{-1}	Y = .37 + .08X	0.49
N content stalks kg ha^{-1}	Y = .95 + 6.04X	0.66
IVOMD grain dag kg^{-1}	---	---
DOM grain kg ha^{-1}	---	---
IVOMD stalks dag kg^{-1}	---	---
DOM stalks kg ha^{-1}	--	--

*X = Coded N rate: 1 = 0, 2 = 56, 3 = 112, 4 = 168, and 5 = 224 kg N ha^{-1}

**NS = Not significant at the 0.05 level of probability [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] centration [illegible] increased [illegible] kg N ha^{-1} [illegible] tively at [illegible] fertilizer did [illegible] at locations [illegible] however [illegible] fertilizer caused Ca to [illegible] and the [illegible] Mg to [illegible] in concentration (Table 2-7) [illegible] had a better rainfall distribution [illegible] increased uptake of nutrients could have occurred providing higher concentrations of elements in the grain.

The concentration of N in corn stalks increased up to the 224 kg N ha^{-1} rate at location 1 and up to the 168 kg N ha^{-1} rate at locations 2 and 3 (Table 2-8). Regression equations for stalk N concentrations versus rate of N application are given in Table 2-6. Correlations were low for N concentration in stalks when compared with N rates. Phosphorus, K, Mg, Fe, or Mn concentrations in stalks were not affected by rate of N (Table 2-8). Calcium concentration increased in response to 56 kg N ha^{-1} at location 1 and to 168 kg N ha^{-1} at location 3. Zinc was highest in the control plots and did not respond to N application.

The content of N in corn grain increased in response to 56 kg N ha^{-1} at location 1 and to the 112 kg N ha^{-1} rate at locations 2 and 3 (Table 2-9). Rhoads and Stanley (1984) stated that the amount of grain produced for each kg of N contained in the aerial portion of corn plants ranges from 30 to 60 kg. In the current study, grain yield per kg N in the plant ranged from 25 to 44 kg for 0 to 56 kg N ha^{-1} applied

[illegible]

N Treatment	Location I	 II	 III	Average
kg N ha^{-1}		dag kg^{-1}		
0	[illegible]	1.40	0.80	[illegible]
56	[illegible]	1.30	1.00	[illegible]
112	1.60	1.50	1.20	1.40
168	1.60	1.50	1.40	1.50
224	1.80	1.50	1.50	[illegible]
LSD 0.05	0.18	0.13	0.18	
		P dag kg^{-1}		
0	0.22	0.34	0.34	0.30
56	0.30	0.38	0.35	0.34
112	0.30	0.45	0.36	0.37
168	0.29	0.44	0.37	0.37
224	0.25	0.53	0.39	0.39
LSD 0.05	NS*	0.08	NS	
		K dag kg^{-1}		
0	0.38	0.48	0.42	0.43
56	0.39	0.51	0.40	0.43
112	0.44	0.54	0.40	0.46
168	0.46	0.53	0.39	0.46
224	0.41	0.54	0.40	0.45
LSD 0.05	NS	0.03	NS	

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}		Ca dag kg^{-1}		
0	[illegible]	[illegible]	7	[illegible]
56	[illegible]	[illegible]	8	[illegible]
112	[illegible]	[illegible]	8	[illegible]
168	[illegible]	[illegible]	13	[illegible]
224	[illegible]	[illegible]	13	[illegible]
LSD 0.05	[illegible]	[illegible]	NS	
		Mg dag kg^{-1}		
0	0.11	0.18	0.11	[illegible]
56	0.12	0.18	0.11	[illegible]
112	0.13	0.23	0.13	[illegible]
168	0.15	0.22	0.13	[illegible]
224	0.12	0.23	0.13	[illegible]
LSD 0.05	NS	0.03	NS	
		Fe mg ha^{-1}		
0	30	47	53	45
56	32	47	43	41
112	30	55	73	53
168	35	63	83	60
224	33	62	68	54
LSD 0.05	NS	NS	NS	

Table [illegible] (continued)

[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]	[illegible]	
kg N ha^{-1}		Mn mg ha^{-1}		
0	[illegible]	[illegible]	5.0	[illegible]
56	[illegible]	[illegible]	6.0	[illegible]
112	[illegible]	[illegible]	7.0	[illegible]
168	[illegible]	[illegible]	7.0	7.0
224	[illegible]	[illegible]	7.0	7.0
LSD 0.05	NS	NS	NS	
		Ca kg ha^{-1}		
0	[illegible]	[illegible]	1.3	2.0
56	[illegible]	[illegible]	1.3	1.8
112	[illegible]	[illegible]	1.3	1.9
168	[illegible]	[illegible]	1.0	1.9
224	[illegible]	[illegible]	1.0	2.0
LSD 0.05	[illegible]	[illegible]	NS	
		Zn mg ha^{-1}		
0	22	50	31	34
56	18	59	31	36
112	18	60	31	36
168	19	59	25	34
224	23	57	27	36
LSD 0.05	NS	NS	NS	

*NS = Not significant at the 0.05 level of probability.

[illegible]

N Treatment	[illegible]			[illegible]
	1	2	3	
kg N ha^{-1}		N dag kg^{-1}		
0	[illegible]	[illegible]	0.76	[illegible]
56	[illegible]	[illegible]	0.51	[illegible]
112	[illegible]	[illegible]	[illegible]	[illegible]
168	0.73	[illegible]	[illegible]	[illegible]
224	0.82	[illegible]	[illegible]	[illegible]
LSD 0.05	0.13	[illegible]	[illegible]	
		P dag kg^{-1}		
0	0.20	0.31	0.24	[illegible]
56	0.21	0.23	0.18	[illegible]
112	0.22	0.20	0.14	[illegible]
168	0.20	0.21	0.15	[illegible]
224	0.25	0.20	0.18	0.21
LSD 0.05	NS*	NS	0.03	
		K dag kg^{-1}		
0	0.90	1.20	1.00	1.00
56	0.90	1.10	1.10	1.00
112	1.10	1.20	1.10	1.10
168	0.90	1.20	1.10	1.10
224	0.90	1.00	1.00	1.00
LSD 0.05	NS	NS	NS	

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			
0	[illegible]	[illegible]	[illegible]	0.18
56	[illegible]	[illegible]	[illegible]	0.21
112	[illegible]	[illegible]	[illegible]	0.24
168	[illegible]	[illegible]	[illegible]	0.27
224	[illegible]	[illegible]	[illegible]	0.23
LSD 0.05	[illegible]	[illegible]	[illegible]	
	Mg [illegible]			
0	0.26	[illegible]	[illegible]	0.23
56	0.30	[illegible]	[illegible]	0.24
112	0.30	[illegible]	[illegible]	0.24
168	0.28	[illegible]	[illegible]	0.24
224	0.26	[illegible]	[illegible]	0.22
LSD 0.05	NS	NS	[illegible]	
	Fe mg kg^{-1}			
0	60	70	70	70
56	60	80	60	70
112	70	70	70	70
168	60	80	70	70
224	60	70	80	70
LSD 0.05	NS	NS	NS	

[illegible] continued

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}		Mn mg kg^{-1}		
0	20	20	20	[illegible]
56	20	30	40	[illegible]
112	20	20	40	[illegible]
168	20	30	50	30
224	20	30	40	30
LSD 0 05	NS	NS	NS	
		Cu mg kg^{-1}		
0	3.0	2 8	2 0	[illegible]
56	3.3	2 8	2 5	[illegible]
112	4.5	4 0	3 2	3.9
168	3.5	4 0	4 0	3.8
224	3 6	4 3	3 0	3.6
LSD 0 05	NS	0 8	0 7	
		Zn mg kg^{-1}		
0	20	50	30	30
56	10	30	20	20
112	10	20	10	20
168	10	20	10	20
224	10	20	10	10
LSD 0 05	3	9	8	

[*] NS = Not significant at the 0 05 level of probability

[illegible] ammonia.

N Treatment	Location			Average
	1	[illegible]	[illegible]	
kg N ha^{-1}	N kg ha^{-1}			
0	[illegible]	3	[illegible]	3
56	[illegible]	[illegible]	18	18
112	17	[illegible]	27	[illegible]
168	18	[illegible]	31	33
224	12	33	38	34
LSD 0.05	6	[illegible]	9	
	P kg ha^{-1}			
0	1.0	1.0	1.0	1.0
56	3.0	6.0	7.0	5.0
112	3.0	12.0	8.0	8.0
168	3.0	14.0	9.0	9.0
224	2.0	19.0	10.0	10.0
LSD 0.05	1.0	4.0	3.0	
	K kg ha^{-1}			
0	1.0	1.0	1.0	1.0
56	5.0	8.0	7.0	2.0
112	5.0	14.0	9.0	9.0
168	5.0	17.0	9.0	10.0
224	1.0	19.0	10.0	
LSD 0.05	2.0	5.0	3.0	

[illegible] Continued

N applied	Location 1	2	[illegible]	Average
kg N ha^{-1}	Cu g [illegible]			
0	0.01	[illegible]	[illegible]	[illegible]
56	0.06	0.12	[illegible]	0.10
112	0.03	0.34	[illegible]	[illegible]
168	0.05	0.48	[illegible]	[illegible]
224	0.03	0.43	[illegible]	[illegible]
LSD 0.05	0.02	0.13	[illegible]	
	Mg kg [illegible]			
0	0.3	0.4	[illegible]	[illegible]
56	1.4	2.8	[illegible]	[illegible]
112	1.4	6.2	[illegible]	[illegible]
168	1.6	7.0	[illegible]	[illegible]
224	0.8	8.3	[illegible]	[illegible]
LSD 0.05	0.6	2.1	1.1	
	Fe g ha^{-1}			
0	7	1	2	12
56	4	7	8	6
112	3	15	16	11
168	4	20	19	14
224	2	22	18	20
LSD 0.05	3	7	7	

[illegible] continued

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}		Mn g ha^{-1}		
0	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	1.0	[illegible]	0.80
112	[illegible]	[illegible]	[illegible]	1.50
168	0.60	[illegible]	[illegible]	1.50
224	0.30	[illegible]	[illegible]	1.80
LSD 0.05	0.10	[illegible]	[illegible]	
		Cu g ha^{-1}		
0	0.60	0.06	0.04	0.05
56	0.20	0.30	0.20	0.20
112	0.20	0.60	0.30	0.40
168	0.30	0.70	0.20	0.40
224	0.20	0.80	0.20	0.04
LSD 0.05	0.10	0.10	0.10	
		Zn g ha^{-1}		
0	0.5	1.0	0.8	3.0
56	2.0	9.0	6.0	6.0
112	2.0	20.0	7.0	10.0
168	2.0	20.0	6.0	9.0
224	1.5	20.0	7.0	10.0
LSD 0.05	0.6	5.0	2.0	

[illegible] similarly [illegible] 56 kg N ha^{-1}. Potassium, Ca, Mg, and Mn contents all increased in response to the 56 kg N ha^{-1} rate at locations 2 and 3. At location 1, Ca and Cu contents increased to rates of 56 and 112 kg N ha^{-1}, respectively. There was no significant response to N rate of other nutrients at location 1 (Table 10). [illegible] and Welch (1970) found that P uptake may be restricted by application of anhydrous ammonia. Fribourg et al. (1976) stated that the content of N, P, K, Ca, and Mg exhibits considerable variability. This was not unexpected since soil drainage, fertility, climatic conditions and fertilizer practice can influence yield levels and crop content of each element. Hanway (1962b) reported that the mineral nutrition of corn plants in the field appears to influence grain yields mainly by affecting the leaf area produced early in the season, and the length of time the leaves remain alive and functioning during grain formation. Yamaguchi (1974) found in a study of tropical corn that leaves die quickly after silking and the duration from silking to harvest is short, hence leaf area duration (LAD) is smaller. The reason for this is unknown, but it seems that high temperature is one of the important factors since senescence is slow when temperatures are cooler. Nair and Babu (1975) stated that Zn-P-Fe interactions occurred in the corn plant. Higher P levels reduced Zn concentration in the shoots by more than half as compared to roots. The mobility of Zn and Fe was impeded from root to shoot in their study.

In vitro organic matter digestibility increased only in corn stalks at locations 1 and 2; however, digestible organic matter (DOM)

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}		N kg ha^{-1}		
0	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	14	[illegible]
112	[illegible]	18	[illegible]	[illegible]
168	[illegible]	[illegible]	[illegible]	24
224	[illegible]	[illegible]	31	26
LSD 0.05	[illegible]	[illegible]	[illegible]	
		P kg ha^{-1}		
0	3.0	[illegible]	3.1	[illegible]
56	5.4	[illegible]	[illegible]	5.6
112	5.7	6.2	4.7	[illegible]
168	6.2	9.1	5.3	[illegible]
224	6.4	8.6	7.5	7.5
LSD 0.05	1.8	2.5	1.4	
		K kg ha^{-1}		
0	15	14	13	14
56	25	33	30	29
112	30	39	37	35
168	29	50	36	38
224	24	46	40	37
LSD 0.05	9	13	11	

Table [illegible]. Continued

N Treatment	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}	Ca kg ha^{-1}			
0	2.0	[illegible]	[illegible]	[illegible]
56	6.4	[illegible]	[illegible]	5.9
112	5.6	6.0	[illegible]	7.5
168	6.4	[illegible]	[illegible]	9.2
224	5.0	[illegible]	12.6	8.5
LSD 0.05	1.7	[illegible]	[illegible]	
	Mg kg ha^{-1}			
0	4.1	[illegible]	2.3	[illegible]
56	7.9	7.4	4.7	[illegible]
112	8.1	8.1	6.2	[illegible]
168	8.7	10.9	6.9	8.9
224	6.3	9.4	7.9	9
LSD 0.05	NS*	2.9	1.6	
	Fe g ha^{-1}			
0	9	8	9	8
56	17	22	17	19
112	19	23	24	22
168	21	33	26	26
224	22	29	32	27
LSD 0.05	NS	9	8	

[illegible]

[illegible]	[illegible]			[illegible]
	1	1	1	
[illegible]	Mn g ha^{-1}			
[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	[illegible]	7	11	[illegible]
[illegible]	[illegible]	8	15	[illegible]
[illegible]	[illegible]	12	16	[illegible]
[illegible]	[illegible]	11	[illegible]	[illegible]
LSD 0.05	NS	4	5	
	Cu g ha^{-1}			
0	0.4	0.3	0.3	[illegible]
56	0.9	0.8	0.7	[illegible]
112	1.2	1.3	1.1	[illegible]
168	1.1	1.7	1.4	[illegible]
224	1.0	1.9	1.2	[illegible]
LSD 0.05	0.1	0.1	0.1	
	Zn g ha^{-1}			
0	3	6	4	[illegible]
56	2	8	6	[illegible]
112	4	8	5	[illegible]
168	3	9	5	[illegible]
224	3	8	7	[illegible]
LSD 0.05	NS	3	3	

*NS = Not significant at the 0.05 level of probability.

[illegible] and [illegible] There [illegible] and a quadratic [illegible] (Table 2-6). The IVOMD o[illegible] averaged over all locations [illegible] effect since DOM ha[illegible] [illegible] et al. (1980) in comp[illegible] in whole plant [illegible] harvest, 73% vs 72 [illegible] variables, nutrient [illegible] found in Appendix Tables [illegible]

[illegible] of the youngest mature le[illegible] 40 days [illegible] that N concentration was increased by applic[illegible] N ha^{-1} (Table 2-12) The only other nutrient that was [illegible] fertilizer was Fe which increased to 168 kg N ha^{-1} When the [illegible] plant was sampled at 40 days after emergence, there was a change [illegible] plant concentration of N, Ca, Mg, Fe, Mn and Cu to N rates of 112, [illegible] 56, 112, and 112 kg N ha^{-1}, respectively (Table 2-13) When [illegible] ear leaf was sampled at the bloom stage of maturity, fertilizer N [illegible] affected OM and IVOMD at 224 and 56 kg N ha^{-1}, respectively, when averaged over the two locations (Table 2-14) Nitrogen values ranged from 1.87 to 2.78 dag kg^{-1} at 40 days post emergence for youngest mature leaf, 1.61 to 2.78 dag kg^{-1} for the whole plant at 40 days, and 1.66 to 2.43 dag kg^{-1} for the ear leaf at bloom (Tables 2-12 to 2-14) Critical nutrient levels (CNL) for corn were first established by Tyner (1946). He proposed CNL levels of 2.9 dag kg^{-1} N, 0.29 dag kg^{-1} P, and 1.3 dag kg^{-1} K for the sixth leaf at silking Since then many CNL

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}	[illegible]					
0	99.[illegible]	[illegible]	99.0	[illegible]	99.2	[illegible]
56	99.[illegible]	[illegible]	98.8	[illegible]	99.2	[illegible]
112	99.[illegible]	[illegible]	98.8	[illegible]	99.0	[illegible]
168	98.3	[illegible]	98.8	97.0	98.6	[illegible]
LSD 0.05	0.5	[illegible]	NS*	NS		
	OM Mg ha^{-1}					
0	[illegible]	[illegible]	0.73	1.08	0.23	1.[illegible]
56	1.1[illegible]	[illegible].51	1.76	2.89	1.31	2.70
112	1.0[illegible]	2.60	[illegible].65	3.19	1.86	2.89
168	1.10	2.98	3.[illegible]1	4.17	2.15	3.57
224	0.6[illegible]	2.49	3.53	4.20	1.43	3.35
LSD 0.05	0.42	0.71	0.85	0.96		
	IVOMD dag kg^{-1}					
0	74.0	45.[illegible]	77.9	46.0	76.0	45.6
56	71.8	48.3	76.0	40.9	74.0	44.6
112	74.9	49.5	74.5	38.5	74.7	44.0
168	76.1	50.5	71.6	39.6	76.1	45.1
224	77.6	50.4	70.6	41.5	74.1	47.5
LSD 0.05	NS	3.7	NS	3.4		
	DOM Mg ha^{-1}					
0	0.18	0.59	0.14	0.52	0.16	0.61
56	0.84	1.27	0.82	1.20	0.83	1.24
112	0.82	1.34	1.47	1.26	1.15	1.28
168	0.84	1.59	1.85	1.71	1.35	1.65
224	0.51	1.41	1.79	1.77	1.15	1.60
LSD 0.05	0.32	0.36	0.53	0.41		

*NS = Not significant at the 0.05 level of probability.

Table 3.12. Tissue analysis of corn leaves at 40 days as influenced by [illegible]

Treatment	N		P		K		Ca		Mg		[illegible]	
	Location		Location		[illegible]		[illegible]		[illegible]		[illegible]	
	1	[illegible]	1	2	1	[illegible]	[illegible]	[illegible]	1	[illegible]	1	[illegible]
kg ha^{-1}	----------		----------		dag kg^{-1}		----------				[illegible] kg^{-1}	
0	1 89	1 84	0 35	0.23	2 11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	2 65	2.15	0 24	0 25	1 81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	2 47	2 75	0 24	0.19	1 68	1 94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	2 51	2 61	0 28	0 20	2 00	1 80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	2 60	2.96	0 26	0 22	1 92	1 93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	04	54	NS*	NS	NS	NS	NS	04	[illegible]	[illegible]	[illegible]	[illegible]

Table 2-12 Extended

N Treatment	Mn		[illegible]		[illegible]		[illegible]		[illegible]	
	Location		[illegible]		[illegible]		[illegible]		Location	
	1	2	1	2			1	2	1	2
kg ha^{-1}	mg kg^{-1}						dag kg^{-1}			
0	29.75	31.00	4.75	5.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	30.00	29.25	3.75	4.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	31.50	35.50	4.25	5.50	16.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	34.75	28.75	3.75	5.75	16.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	38.00	33.25	4.25	6.00	15.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	NS	NS	NS	NS	[illegible]	[illegible]	[illegible]	NS	NS	[illegible]

[a] NS Not significant at the .05 level [illegible]

[illegible] Tissue anal[illegible] locations

Treatment N	N		[illegible]		[illegible]		[illegible]		Mg		[illegible]	
	Location		Location		Location		Location		Location		Location	
	1	2	1	2	1	2	1	2	1	2	1	2
kg ha^{-1}	[illegible]										[illegible]	
0	[illegible]	1.67	0.2[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]	0.[illegible]1	0.26	0.26	70	[illegible]
56	1.97	1.69	0.28	0.[illegible]5	1.[illegible]	1.63	0.44	0.39	0.34	0.30	82	100
112	2.25	2.21	0.32	0.24	1.62	1.59	0.46	0.39	0.40	0.28	97	9[illegible]
168	2.53	2.39	0.34	0.27	1.72	1.58	0.43	0.42	0.39	0.31	100	[illegible]
224	2.37	3.34	0.38	0.32	1.74	1.59	0.49	0.39	0.39	0.32	100	[illegible]
LSD .05	.30	.31	NS*	NS	.09	NS	.06	.08	.08	[illegible]	[illegible]	[illegible]

Table [illegible] continued

Treatment	[illegible]		Cu		[illegible]		OM		IVOMD	
	Location		Location		Location		Location		[illegible]	
	1	2	1	2	1	[illegible]	1	2	1	[illegible]
kg ha^{-1}	———— mg kg^{-1} ————						———— [illegible] ————			
0	25	17	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60.53	60.[illegible]
56	25	30	7	5	[illegible]	1[illegible]	[illegible]	96.48	62.08	58.9[illegible]
112	30	32	6	[illegible]	[illegible]	15	90.38	96.07	62.35	59.[illegible]
168	34	31	6	[illegible]	17	18	90.28	95.96	[illegible]	[illegible]
224	32	30	7	[illegible]	15	19	80.20	95.98	[illegible]	[illegible]
LSD 05	NS	10	1	[illegible]	NS	[illegible]	NS	[illegible]	[illegible]	[illegible]

*NS = Not significant at the 0.05 level of probability.

Table 2-14 Tissue analysis of [illegible]

N Treatment	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
$kg\ ha^{-1}$	[illegible]											
0	1.67	1.65	0.30	0.28	2.87	2.38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	2.58	1.66	0.38	0.23	2.08	2.96	0.36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	2.67	1.96	0.24	0.20	1.76	2.73	0.38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	2.37	2.06	0.28	0.19	2.65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	2.57	2.30	0.26	0.20	2.39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	.32	NS[a]	NS	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 2.14. Extended

N Treatment	[illegible]		[illegible]		[illegible]		OM		[illegible]	
	Location		Location		Location		Location		Location	
	1	2	1	[illegible]	1	[illegible]	1	[illegible]	[illegible]	[illegible]
kg ha^{-1}	------------------- mg kg^{-1}						------------ dag kg^{-1}			
0	37.25	33.25	5.00	4.50	[illegible]	[illegible]	[illegible]	36.15	[illegible]	[illegible]
56	37.50	30.00	4.75	3.25	14.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	40.50	30.25	4.25	4.50	13.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	40.00	35.00	4.00	3.75	11.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	48.00	31.25	4.25	4.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	NS	NS	NS	NS	3	NS	[illegible]	[illegible]	[illegible]	[illegible]

[a] NS = Not significant at the 0.05 level of probability.

[illegible] CNL [illegible] [illegible] to [illegible] dag kg^{-1} [illegible] measured in the ear leaf at [illegible]. In the current study, no rate of N gave these levels of N in the [illegible] leaf when sampled. Phosphorus tended to decrease with increasing rates of N, and only the control and 56 kg N ha^{-1} would meet CNL requirements for P. Potassium met or exceeded the CNL requirement [illegible]

Correlation coefficients for nutrient concentration used to predict grain, stalk, and whole plant DM yields by three sampling methods are found in Table 2-15. When the youngest mature leaf was sampled at 40 days post emergence there was a high positive correlation between N and Ca concentration in the leaf with final grain, stalk, and whole plant DM yield. Potassium was negatively correlated to grain yield. Zinc was also negatively correlated not to stalk and whole plant yield as well as grain yield. Phosphorus, Mg, Fe, Mn, Cu, DM, OM, and IVOMD were not well correlated with grain, stalk, and whole plant yield at either locations utilizing this sampling technique. Calcium and N were well correlated with final yield but neither nutrient met sufficiency levels in this study. At this stage of growth, N concentration should range from 3.5 to 5 dag kg^{-1} and Ca from 0.30-0.70 dag kg^{-1}. Nitrogen and Ca concentration in the youngest mature leaf did not meet the above mentioned levels at any rate of applied N (Table 2-12).

When the whole plant was sampled at 40 days post emergence more nutrients were correlated with final grain, stalk, and whole plant DM yields (Table 2-15). Nitrogen and Ca were again positively correlated

[illegible]

	[illegible]		Whole plant at 40 days		[illegible] leaf [illegible]lking	
	[illegible]		Location		[illegible]	
			1	2	1	[illegible]
[illegible] $^{-1}$			[illegible] kg ha^{-1}			
[illegible]	[illegible]	[illegible]	[illegible] 69	0 74	0 71	0 7[illegible]
[illegible]	[illegible]	[illegible]	NS	NS	NS	NS
[illegible]	[illegible]	[illegible]	-0 56	-0 44	NS	NS
[illegible]	[illegible]	[illegible]	0 76	0 66	0 54	0 43
[illegible]	[illegible]	[illegible]	0 52	0 53	NS	NS
Fe	NS	0 39	NS	NS	0 43	-0 43
Mn	NS	NS	NS	NS	NS	NS
Cu	NS	NS	0 44	0 68	NS	NS
Zn	-0 42	-0 56	NS	NS	-0 61	-0 41
DM	NS	-0 41	NS	-0 46	-0 55	NS
OM	NS	NS	NS	-0 39	NS	NS
IVOMD	NS	0 38	NS	-0 53	0 73	NS
			stalks kg ha^{-1}			
N	0 70	0 57	0.50	0.50	0 57	0 57
P	-0 52	NS	0.40	NS	NS	NS
K	NS	-0 38	-0 60	-0 40	NS	NS
Ca	0 58	0 43	0 77	0 68	0 45	0 48
Mg	0 46	NS	0 67	0 65	NS	NS
Fe	NS	NS	0 39	0 40	0 40	NS
Mn	0 49	NS	0 49	0 33	NS	NS
Cu	NS	NS	0 44	0 47	NS	NS
Zn	-0 51	-0 50	NS	NS	-0 62	NS
DM	NS	0 47	NS	-0,53	-0 66	NS
OM	NS	NS	NS	NS	0 38	NS
IVOMD	NS	0 43	0 39	0 65	0 69	0 43

Table [illegible]

	Youngest mature leaf at 40 days		[illegible]		[illegible]	
	Location		[illegible]		[illegible]	
	1	2	[illegible]	[illegible]	[illegible]	[illegible]
dag kg^{-1}	----	-----	whole plant kg ha^{-1}			
N	0.73	0.61	0.49	0.65	[illegible]	[illegible]
P	0.40	NS	NS	NS	[illegible]	[illegible]
K	NS	0.45	0.62	-0.44	[illegible]	[illegible]
Ca	0.65	0.45	0.81	0.71	[illegible]	[illegible]
Mg	0.53	NS	0.66	0.62	[illegible]	[illegible]
Fe	NS	NS	0.40	NS	[illegible]	[illegible]
Mn	0.37	NS	0.38	NS	[illegible]	[illegible]
Cu	NS	NS	0.46	0.60	[illegible]	[illegible]
Zn	-0.50	-0.56	NS	NS	-0.65	[illegible]
DM	NS	-0.46	NS	-0.52	-0.66	[illegible]
OM	NS	NS	NS	NS	NS	[illegible]
IVOMD	NS	0.43	NS	0.62	0.75	[illegible]

*NS - Not significant at the 0.05 level of probability.

[illegible] [illegible] u and Mg we[illegible] [illegible]

When the ear leaf was sampled at mid-silk [illegible], and Zn were well correlated at both locations to predict grain yield. Nitrogen and Ca concentrations in the leaf were positively correlated [illegible] Zn was negatively correlated. Nitrogen, Ca, and IVOMD were positively correlated to stalk and whole plant DM yield. The reason [illegible] IVOMD being correlated to yields of stalk and whole plant [illegible] IVOMD of grain does not vary much but is directly influenced by [illegible] availability, DM accumulation, source sink, and nutrient uptake in the vegetative portions of the plant. Bennett et al. [illegible] noted grain yield increases with increasing N and P levels in the ear leaf. Gallaher et al. (1972) found that in corn, seasonal variation in rainfall, temperature, and sunlight caused large differences in yield and ear leaf concentration of K. Hanway (1962c) reported that several researchers have found high positive correlations between the percentages of N, P, and K in corn leaves at silking time and the yield of grain.

Conclusions

Grain, residue, and whole plant DM showed a positive response to the 56 kg N ha^{-1} rate at two locations. At the third location, a significant increase for the yield parameters occurred in response to the 112 kg N ha^{-1} rate. There was a 250% increase for the corn grain to residue ratio over the control. Insufficient rainfall during the silking through ear fill period decreased grain yields more than

[illegible]
highest r[illegible]. Grain, stalk and whole [illegible] locations 2 and 3, but increased quadrati[illegible] and whole plant DM yield due to moisture st[illegible] nutrients varied with N fertilizer rate at each location. Nitrogen content increased linearly at all locations. Total grain yield per kg of N content ranged from 25 to 44 kg ha^{-1}. The N content of stalks responded the same as grain. The concentration and content of most other nutrients did not respond to N rate at any location or only increased in response to the 56 kg N ha^{-1} rate.

The analysis of diagnostic samples indicated that N and Fe were the only elements increased by N rate when youngest mature leaves were sampled at 40 days past emergence. Whole plant samples at 40 days exhibited a change in nutrient concentration for N, Ca, Mg, Fe, Mn, and Cu. Ear leaf sampled at mid-silk showed an increase to N rate for OM and IVOMD. The concentration of N and P were lower than the CNL values recommended by Tyner (1946) for sufficiency levels in corn ear leaves. Only K met the CNL values recommended by various researchers. Nutrient concentration by three sampling methods as predictors of grain yield indicate that N, Ca, and Zn were all well correlated with grain, stalk, and whole plant DM yield when the youngest mature leaf at 40 days was utilized. When the whole plant at 40 days post emergence was sampled, N and Ca were positively correlated to final yields with K being negatively correlated. Copper and Mg were also positively correlated with final DM yields when this sampling technique was utilized. When the ear leaf at silking was sampled, N and Ca were positively [illegible] [illegible] negatively correlated with grain yield. [illegible]

Ca, and IVOMD were [illegible] related to stalk and whole plant DM yield.

CHAPTER 3

ANHYDROUS AMMONIA AS A SOURCE OF NITROGEN FOR GRAIN SORGHUM PLANTED INTO BAHIAGRASS SOD BY MINIMUM TILLAGE METHODS

Introduction

[illegible] (Sorghum bicolor L. Moench) is gaining popularity [illegible] feed grain. It has been studied in multicr[illegible] 1977a) and fits well into a combine typ[illegible] of planting is not as limiting and yield [illegible] doing is greater than from corn (Zea mays L.) [illegible] soybeans (Glycine max L. Merrill) (Larson and Maranville, 1977). [illegible] some conditions higher grain yields have been produced with grain sorghum than with corn (Lutrick, 1978). Vast areas in the Southeast are occupied by perennial sods which could be more fully utilized if interplant multicropping minimum tillage systems were feasible. Multicropping systems utilizing bahiagrass (Paspalum notatum L. Flugge) and followed by grain sorghum have been studied (Lundy et al., 1974; Prine and Robertson, 1968; Robertson et al., 1976). However, only a few of these studies involved in-row subsoiling and none utilized anhydrous ammonia as the sole source of N.

Grain sorghum has high yield potential (Smith, 1966) and produces grain which can be increased appreciably in protein content. Magnitude of grain sorghum response to N fertilizer addition is indicated by findings of Miller et al. (1964) and Nelson (1952). Grain sorghum [illegible] depressed [illegible] n when [illegible] tendency to produce [illegible] grain [illegible] content when corn would likely [illegible] n very [illegible] sorghum tends to give less yield increase for a given [illegible] which may be due in part to its ability to [illegible] the soil This behavior may be due to its [illegible] to delay maturity allowing for more uptake of [illegible] The level of N to which grain sorghum will respond varies [illegible] with environmental factors, soil type, fertilizer application [illegible] conditions (Lutrick, 1978) Johnson and Cummins ([illegible] [illegible] that in Georgia 112 kg N ha^{-1} applied anytime up to [illegible] planting would give maximum yields of forage sorghum [illegible] Onken (1968) observed a yield increase for irrigated grain sorghum up to 180 kg N ha^{-1} with the 135 kg N ha^{-1} rate giving the optimum response They obtained an 8 year average grain yield increase of 1350 kg ha^{-1} from the first 45 kg of N, 390 kg grain ha^{-1} from the second 45 kg N, and 225 kg grain ha^{-1} from the third 45 kg N Lutrick (1978) applied ammonium nitrate at rates of 0 to 188 kg N ha^{-1}. In general, the yield of grain sorghum did not increase significantly when more than 75 kg N ha^{-1} was applied on a yearly basis The protein concentration increased in the grain of sorghum for increments of N up to and including 112 kg ha^{-1}. He then deduced that the recommended rate of applied N for grain sorghum should be 112 kg ha^{-1}.

No-tillage planting a summer crop such as grain sorghum into a grass sod could help control erosion problems due to wind or water. Therefore, methods for chemically suppressing late spring and summer [illegible] following [illegible] in the pasture sod [illegible] residues for [illegible] to graze in th[illegible] [illegible] increase the value and availability of mul[illegible] sorghum with bahiagrass sods.

The objective of this study was to determine the effect of anhydrous ammonia as the sole source of N in no-tillage [illegible] planted sorghum into bahiagrass sod.

Materials and Methods

All materials and methods for this experiment were identical to those previously presented in Chapter [illegible] with only a few differences as discussed below.

The grain sorghum experiment was conducted at three previously described locations during 1983 and 1984. The experiment was in a randomized complete block design with six replications utilizing DeKalb 'DK59' grain sorghum planted into 15-year-old bahiagrass (cv. 'Pensacola') sods. All sorghum was planted at a population of 124,000 plants ha^{-1}. Two rows 6 m in length were hand harvested from each plot for yield determination. The samples were weighed and a five plant subsample taken for dry matter (DM) determination and chemical analyses. At 40 days post emergence five whole plants and five youngest mature leaves were collected from each plot to determine diagnostic potential of plant part sampling and analyses. At sorghum bloom, five leaves, each positioned three leaves down the stalk from the flag leaf, were collected from each plot for chemical analyses.

[illegible]

screen and [illegible] in air-tight [illegible]. Planting dates, sampling, and [illegible] dates are listed in [illegible]

Soil [illegible] taken following final harvest. Soil test results are [illegible] of Table B-1

Results and Discussion

Rainfall was limiting during the bloom to grain fill period particularly at location 1 during 1983 (Table 3-2). As a result of interactions between N rate and locations, the data in this study were analyzed by location. Sivakumar et al. (1978) reported that the main components of sorghum yield which were significantly affected by drought in the case of non-irrigated plots were tertiary branches per secondaries, seed number per panicle, and seed size. The reduction in these components was 46, 26, and 28%, respectively, in their study. Their data point out the importance of the availability of a few additional cm of water to a sorghum crop under water stress and benefits that should accrue from such water application.

Grain DM yield increased to the 56 kg N ha^{-1} rate at locations 1 and 2 and to the 112 kg N ha^{-1} rate at location 3 (Table 3-3). Residue yield increased at all three locations to the 112 kg N ha^{-1} rate, while whole plant yield responded positively to the 56 kg N ha^{-1} rate at locations 1 and 3 and to the 112 kg N ha^{-1} rate at location 2.

Grain/residue, percent grain, and the number of plants ha^{-1} varied at each location and contributed to the variation of DM yields and

Table 3-1 Planting and harvesting dates, and plant sampling [illegible] or corn and grain sorghum planted into bahiagrass sod

Operation for Sorghum	[illegible]		[illegible]
	Location 1	[illegible]	[illegible]
	month/d[illegible]		
1 Planting date	6/23	6/9	[illegible]
2 Youngest mature leaf	6/[illegible]	[illegible]	[illegible]
3 Whole plant	[illegible]	[illegible]	
4 Third leaf from [illegible]	[illegible]	[illegible]	[illegible]
5 Harvest at maturity	[illegible]	[illegible]	[illegible]
6 Soil samples	[illegible]	[illegible]	[illegible]

Table [illegible]. [illegible] during [illegible] sorghum was [illegible]

	1983		198[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			
[illegible]			
[illegible]			[illegible]
[illegible]			[illegible]
[illegible]			
[illegible]	[illegible]		[illegible]
[illegible]			[illegible]
[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		
[illegible]			
[illegible]		[illegible]	
7/25	20	[illegible]	76
7/30	19		18
8/5	33		38
8/10			
8/15			18
8/20	76	[illegible]	51
8/25			
8/30			
9/5		[illegible]	10
9/10			

Table [illegible] [illegible] response [illegible] ammoni[illegible]

N Treatment	Location 1	Location 2	Location 3	Aver[illegible]
kg N ha^{-1}	Grain yield [illegible]			
0	[illegible]	0.20	[illegible]	[illegible]
56	1.92	0.77	[illegible]	1.52
112	1.86	1.08	[illegible]	1.92
168	[illegible]	1.48	[illegible]	[illegible]
224	2.50	1.36	[illegible]	1.92
LSD 0.05	0.60	0.48	[illegible]	
	Residue Mg ha^{-1}			
0	1.58	2.08	0.69	[illegible]
56	2.96	4.64	2.14	3.25
112	3.65	5.86	3.02	4.16
168	3.85	5.76	2.99	4.20
224	4.30	6.41	2.32	4.34
LSD 0.05	0.54	1.21	0.52	
	Whole plant Mg ha^{-1}			
0	2.10	2.30	1.20	1.90
56	4.92	5.37	3.97	4.72
112	5.56	6.88	5.83	6.10
168	6.12	7.28	6.14	6.48
224	6.80	7.78	4.18	6.22
LSD 0.05	0.90	1.50	1.00	

[illegible]

[illegible]	Location 1	2	3	[illegible]
[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD 0 [illegible]	0 18	0 06	NS*	
	------------ Grain dag kg^{-1} --			
0	[illegible]	9	41	[illegible]
56	[illegible]	14	47	[illegible]
112	[illegible]	17	48	[illegible]
168	36	20	51	[illegible]
224	37	17	45	[illegible]
LSD 0 05	10	5	10	
	----------------- Plants ha^{-1} ----			
0	128,680	88,580	66,350	94,540
56	157,950	93,980	76,030	109,310
112	102,000	96,830	83,030	93,950
168	181,610	97,190	76,390	118,400
224	185,060	106,160	60,610	117,280
LSD 0 05	11,800	5,940	14,990	

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*NS = Not significant at the 0 05 level of probability [illegible] sorghum whereas *Caloma sorgh*[illegible] infestation which contributed [illegible] to residue ratio than at the other two locations.

Nitrogen concentration in sorghum grain [illegible] kg^{-1} when averaged over the three locations [illegible] was to the 112 kg N ha^{-1} rate at location 1 [illegible] rate at the other two locations.

Phosphorus and Fe showed an increase [illegible] which was to the 168 kg N ha^{-1} (Table 3-4). [illegible] Ca, Mg, Mn and Zn concentrations in grain were not affected by N fertilizer at [illegible] location

Nitrogen concentration of stalks increased [illegible] 168 kg N ha^{-1} rate at locations 1 and 3 and to the highest rate of [illegible] at location 2 (Table 3-5). Phosphorus reacted similarly at all locations and was highest in the control plots with no N applied. This response is due to dilution effect as more DM was accumulated at higher N rates. Also, it has been reported that NH_3 may have an inhibitory effect on the uptake of P. Potassium increased to N fertility only at location 2 which was to 168 kg N ha^{-1}. Calcium and Mg stalk concentrations increased similarly to the 168 kg N ha^{-1}. Copper concentration of stalks varied and increased to the 224 and 168 kg N ha^{-1} rates at locations 1 and 3, respectively (Table 3-5). Zinc was highest in the control plots at only one location.

Nutrient interactions in grain sorghum are not well documented but several studies have investigated particular ratios and interactions. More than half of the total nutrient uptake in the vegetative growth of

[illegible]

N [illegible]	[illegible]			Average
	1	2	3	
kg N ha^{-1}	---------- N dag kg^{-1} ----------			
0	1.61	1.68	1.15	1.48
56	1.67	1.52	1.14	1.44
112	1.99	1.78	1.34	1.70
168	2.17	1.95	1.53	1.89
224	2.34	2.41	1.90	2.22
LSD 0.05	0.25	0.22	0.17	
	---------- P dag kg^{-1} ----------			
0	0.26	0.44	0.40	0.37
56	0.23	0.32	0.37	0.31
112	0.28	0.34	0.42	0.35
168	0.36	0.32	0.47	0.38
224	0.32	0.36	0.40	0.36
LSD 0.05	NS*	0.10	NS	
	---------- K dag kg^{-1} ----------			
0	0.44	0.55	0.48	0.49
56	0.45	0.55	0.42	0.47
112	0.49	0.55	0.47	0.50
168	0.45	0.57	0.50	0.51
224	0.41	0.52	0.40	0.44
LSD 0.05	NS	NS	NS	

Table 3-[illegible] Continued

N Treatment	[illegible]			[illegible]
	1	[illegible]	[illegible]	
kg N ha^{-1}	[illegible]			
0	[illegible]	[illegible]	[illegible]	[illegible]
56	0.01	0.05	0.02	[illegible] 03
112	0.03	0.06	0.02	[illegible] 03
168	0.02	0.05	0.02	[illegible] 03
224	0.02	0.05	0.02	[illegible] 03
LSD 0.05	NS	NS	NS	
	Mg dag kg^{-1}			
0	0.20	0.30	0.20	0.20
56	0.20	0.30	0.20	0.20
112	0.20	0.30	0.20	0.20
168	0.20	0.30	0.20	0.20
224	0.20	0.30	0.20	0.20
LSD 0.05	NS	NS	NS	
	Fe mg kg^{-1}			
0	44	82	70	65
56	52	80	88	73
112	38	85	122	82
168	72	68	118	86
224	72	83	137	97
LSD 0.05	19	NS	NS	

Table [illegible] (Continued)

N Treatment	Location			Average
	[illegible]	[illegible]	[illegible]	
kg N ha^{-1}		Mn mg kg^{-1}		
0	[illegible]	30	27	[illegible]
56	[illegible]	29	18	[illegible]
112	[illegible]	31	20	[illegible]
168	[illegible]	30	24	[illegible]
274	[illegible]	38	21	[illegible]
LSD 0.05	[illegible]	NS	NS	
		Cu mg kg^{-1}		
0	[illegible]	6.3	2.8	[illegible]
56	[illegible]	5.7	2.7	[illegible]
112	[illegible]	7.0	2.8	[illegible]
168	[illegible]	[illegible]	3.3	5.1
224	[illegible]	6.7	3.0	4.7
LSD 0.05	[illegible]	NS	NS	
		Zn mg kg^{-1}		
0	20	38	28	29
56	18	34	25	26
112	22	37	27	29
168	24	37	28	30
224	20	35	25	27
LSD 0.05	NS	NS	NS	

*NS = Not significant at the 0.05 level of probability

[illegible] stalk nitr[illegible] [illegible] anhydrous ammo[illegible]

Treatment	Locations 1	[illegible]	[illegible]	Average
kg N ha^{-1}		[illegible] g kg^{-1}		
0	0.57	[illegible]	0.48	[illegible]
56	0.50	0.56	0.50	0.53
112	0.83	[illegible]	0.56	0.68
168	0.86	[illegible]	0.76	0.82
224	1.01	[illegible]	0.74	0.92
LSD 0.05	0.14	[illegible]	0.15	
		[illegible] kg ha^{-1}		
0	0.28	[illegible]	[illegible]	0.25
56	0.21	0.16	0.18	0.18
112	0.30	0.17	0.14	0.20
168	0.22	0.20	0.15	0.18
224	0.19	0.18	0.18	0.18
LSD 0.05	0.04	0.03	0.03	
		K kg ha^{-1}		
0	1.28	1.38	1.01	1.22
56	1.23	1.37	1.05	1.22
112	1.43	1.35	1.06	1.28
168	1.30	1.64	1.05	1.33
224	1.40	1.47	0.97	1.28
LSD 0.05	NS*	0.12	NS	

[illegible]

[illegible]	[illegible]			[illegible]
	1	2	3	
kg N ha^{-1}		Ca dag kg^{-1}		
0	[illegible]	0.16	0.20	[illegible]
56	[illegible]	0.18	0.23	[illegible]
112	0.16	0.17	0.30	[illegible]
168	[illegible]	0.17	0.38	[illegible]
224	0.19	0.18	0.31	[illegible]
LSD 0.05	0.02	NS	0.07	
		Mg dag kg^{-1}		
[illegible]	0.20	0.21	0.18	[illegible]
[illegible]	0.24	0.22	0.17	[illegible]
[illegible]	0.27	0.25	0.18	[illegible]
[illegible]	0.27	0.25	0.20	[illegible]
[illegible]	0.29	0.22	0.19	[illegible]
LSD 0.05	0.03	0.03	NS	
		Fe mg kg^{-1}		
0	74	112	72	86
56	84	135	62	94
112	88	118	68	91
168	82	75	73	77
224	102	77	77	85
LSD 0.05	NS	NS	NS	

[illegible] (continued)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}		Mn mg kg^{-1}		
0	[illegible]	[illegible]	34	[illegible]
56	[illegible]	[illegible]	40	[illegible]
112	[illegible]	[illegible]	44	[illegible]
168	[illegible]	[illegible]	47	[illegible]
224	[illegible]	[illegible]	40	[illegible]
LSD 0.05	NS	[illegible]	NS	
		[illegible] mg kg^{-1}		
0	3.4	[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	[illegible]	3.10
112	3.8	[illegible]	[illegible]	3.80
168	[illegible]	[illegible]	4.0	4.00
224	[illegible]	[illegible]	3.0	4.00
LSD 0.05	0.99	NS	0.66	
		Zn mg kg^{-1}		
0	18	31	28	26
56	13	27	20	20
112	15	25	14	18
168	16	25	15	19
224	17	25	15	19
LSD 0.05	NS	NS	*	

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*NS = Not significant at the 0.05 level of probability

[illegible]

[illegible] response to 56, 112 and 168 [illegible]. This response most likely [illegible] sink di[illegible]g locations and the response [illegible] and K content also varied [illegible] to 11 kg ha^{-1}, [illegible] increased to the 56 kg N ha^{-1} [illegible] 1 and to the [illegible] ha^{-1} rate at locations 2 and 3 [illegible] greater growth [illegible]sponse to N fertilizer would [illegible] increased Ca uptake [illegible]ularly where moisture was not [illegible]ium increased [illegible] the 168 kg N ha^{-1} rate at [illegible] but to the 112 kg N ha^{-1} rate at location 3. Iron [illegible] in grain were positively affected by a higher rate of N [illegible] 1. Copper was not affected by N application. Response was [illegible] for Ca, and Zn content was lower at location 1 than at [illegible]ations 2 and 3 which responded similarly (Table 3-6).

Nitrogen content of sorghum stalks was positively affected by N fertilizer at all three locations up to the 224 kg N ha^{-1} rate (Table 3-7). Phosphorus stalk content showed a significant increase to the 112 kg N ha^{-1} rate for locations 1 and 2 with no difference due to N rate at location 3. Potassium, Ca, Mg, Fe, Mn, Cu, and Zn stalk contents varied at each location and responded differently to increasing rates of N. The stalk content of each of these elements was affected by applied N (Table 3-7). Percent OM and IVOMD showed a positive response in stalks to N rate (Table 3-8). However, total OM

[illegible]

N Treatment	[illegible]			[illegible]
	1	2	3	
kg N ha^{-1}		N kg ha^{-1}		
0	8	[illegible]	[illegible]	[illegible]
56	32	[illegible]	21	[illegible]
112	38	[illegible]	38	[illegible]
168	48	[illegible]	47	[illegible]
224	58	[illegible]	38	[illegible]
LSD 0.05	12	[illegible]	8	
		P kg ha^{-1}		
0	1.3	0.9	2.0	[illegible]
56	4.4	2.5	8.9	[illegible]
112	5.4	3.9	11.7	[illegible]
168	8.1	4.4	14.8	[illegible]
224	8.1	5.0	7.6	[illegible]
LSD 0.05	3.1	1.8	3.5	
		K kg ha^{-1}		
0	2.3	1.1	2.4	[illegible]
56	8.4	4.3	7.9	[illegible]
112	9.1	6.4	13.3	[illegible]
188	9.8	8.3	16.0	11.3
224	10.4	7.2	7.7	8.4
LSD 0.05	3.0	2.5	4.0	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Ca kg ha^{-1}			
0	0.12	0.11	0.15	0.13
56	0.51	0.33	0.29	0.38
112	0.49	0.68	0.52	0.56
168	0.44	0.80	0.68	0.64
224	0.50	0.64	0.45	0.53
LSD 0.05	0.22	0.27	0.21	
	Mg kg ha^{-1}			
0	0.80	0.50	1.00	0.80
56	3.06	2.00	2.80	2.60
112	3.80	3.30	5.20	4.10
168	5.20	4.50	6.70	5.50
224	4.68	3.60	3.70	4.00
LSD 0.05	1.60	1.20	1.80	
	Fe g ha^{-1}			
0	2	2	4	2
56	9	6	17	11
112	7	10	33	17
168	6	10	36	21
222	18	11	27	19
LSD 0.05	3	3	10	

[illegible]

N Treatment	[illegible]	[illegible]	[illegible]	Average
kg N ha^{-1}		Mn g ha^{-1}		
0	1.0	0.6	1.4	1.0
56	4.0	2.3	3.4	3.0
112	3.0	3.7	5.6	3.0
168	6.0	4.5	7.3	6.0
224	5.0	5.3	4.0	5.0
LSD 0.05	1.0	1.5	2.0	
		Cu g ha^{-1}		
0	0.2	0.1	0.1	0.1
56	0.7	0.4	0.5	0.5
112	0.8	0.8	0.8	0.8
168	1.1	1.0	1.0	1.0
224	1.1	0.9	0.6	0.8
LSD 0.05	0.3	0.3	0.1	
		Zn g kg^{-1}		
0	1.0	0.8	2.0	1.0
56	4.0	3.0	5.0	3.0
112	4.0	5.0	8.0	6.0
168	5.0	6.0	9.0	7.0
224	5.0	5.0	5.0	5.0
LSD 0.05	2.0	2.0	2.0	

[illegible] Response of [illegible] nutri[illegible] [illegible] rates of [illegible] ammoni[illegible]

[illegible] Treatment	Location 1	[illegible]	[illegible]	Avera[illegible]
[illegible] ha^{-1}		[illegible]		
[illegible]	9	1[illegible]	[illegible]	[illegible]
[illegible]	1[illegible]	[illegible]	[illegible]	1[illegible]
112	13	36	[illegible]	[illegible]
168	33	48	[illegible]	[illegible]
224	44	64	[illegible]	[illegible]
LSD 0.05	7	12	[illegible]	
		[illegible] kg [illegible]		
0	[illegible]	5.0	[illegible]	[illegible]
56	6.0	7.0	3.0	[illegible]
112	11.0	10.0	3.0	8.0
168	6.0	11.0	3.0	8.0
224	8.0	12.0	4.0	
LSD 0.05	2.0	3.0	NS*	
		K kg ha^{-1}		
0	20	29	9	19
56	37	63	31	44
112	53	79	44	59
168	50	94	44	63
224	60	94	29	61
LSD 0.05	10	19	10	

[illegible]

[illegible]	[illegible]			Average
kg N ha^{-1}	[illegible]			
0	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	[illegible]	[illegible]	9.0
168	8.0	[illegible]	[illegible]	10.0
224	8.0	[illegible]	[illegible]	10.0
LSD 0.05	1.0	[illegible]	2.0	
	Mg kg ha^{-1}			
0	3.0	4.0	1.0	3.0
56	7.0	10.0	3.0	7.0
112	10.0	14.0	5.0	10.0
168	10.0	15.0	5.0	10.0
224	12.0	14.0	5.0	10.0
LSD 0.05	2.0	4.0	1.0	
	Fe g ha^{-1}			
0	12	20	6	13
56	24	60	15	33
112	32	70	22	41
168	31	40	25	32
224	44	50	21	38
LSD 0.05	7	30	6	

TABLE [illegible] (continued)

N Treatment	Location			Average
	[illegible]	[illegible]	[illegible]	
kg N ha^{-1}	Mg ha^{-1}			
0	[illegible]	[illegible]	5	6
56	[illegible]	[illegible]	16	16
112	[illegible]	[illegible]	20	20
168	[illegible]	[illegible]	22	90
224	[illegible]	[illegible]	15	20
LSD 0 05	[illegible]	[illegible]	3	
	Mg ha^{-1}			
0	[illegible]	[illegible]	0 2	0 5
56	[illegible]	[illegible]	0 5	1.0
112	[illegible]	[illegible]	0 7	1.7
168	[illegible]	[illegible]	0 8	1.7
224	[illegible]	[illegible]	0 8	1.9
LSD 0 05	[illegible]	[illegible]	0 1	
	mg kg^{-1}			
0	[illegible]	[illegible]	2	3
56	[illegible]	[illegible]	5	7
112	[illegible]	14	5	8
168	[illegible]	14	5	8
224	7	16	5	9
LSD 0.05	[illegible]	4	2	

[*] NS = Not significant at the 0 05 level of probability

[illegible] sorghum grai[illegible] [illegible] monia

	[illegible]tion					
[illegible]	1		2		[illegible]	
	[illegible]	Stalk	Grain	Stalk	[illegible]	[illegible]
[illegible] N ha^{-1}	OM dag kg^{-1}					
0	[illegible]	93.8	98.3	94.9	[illegible]	94.4
[illegible]	[illegible]	94.8	96.5	94.7	[illegible]	94.7
[illegible]	[illegible]	95.5	97.2	94.5	[illegible]	95.0
1[illegible]	[illegible]	95.8	96.8	93.9	[illegible]	94.9
[illegible]4	97.[illegible]	95.7	96.3	97.8	[illegible]	96.8
LSD 0.05	NS*	NS	NS	1.[illegible]		
	OM Mg ha^{-1}					
0	0.5	1.5	0.2	2.0	0.[illegible]	1.80
56	1.9	2.8	0.7	4.4	[illegible]	3.60
112	1.8	3.5	1.1	5.5	[illegible]	4.50
168	2.2	3.7	1.4	5.4	1.80	4.60
224	2.4	3.9	1.3	6.3	1.90	5.10
LSD 0.05	0.6	0.5	0.4	1.2		
	IVOMD dag kg^{-1}					
0	63.9	46.2	69.4	51.2	66.7	48.6
56	58.1	46.6	64.5	51.0	61.3	48.8
112	61.2	59.5	60.2	56.5	60.7	58.0
168	59.5	59.8	66.8	55.6	63.2	57.7
224	60.0	55.0	68.9	57.2	64.4	56.1
LSD 0.05	NS	5.7	7.9	4.2		
	DOM Mg ha^{-1}					
0	0.3	0.7	0.1	1.1	0.2	0.9
56	1.1	1.4	0.5	2.4	0.8	2.0
112	1.1	2.2	0.7	3.3	0.9	2.8
168	1.3	2.3	1.0	3.2	1.2	2.8
224	1.5	2.4	1.0	3.7	1.3	3.0
LSD 0.05	0.4	0.7	0.3	0.8		

*NS = Not significant at the 0.05 level of probability

[illegible]

[illegible] [illegible]lk yield, whole [illegible] and [illegible] locations 1 and 2 (Table 3-9). [illegible] yield paramet[illegible] manner at location 3. [illegible] regression [illegible] Table 3-9. Grain and st[illegible] linearly at all locations [illegible] concentration increased in a cubic [illegible] at location 1 [illegible]

Nutrient analyses of the youngest [illegible] leaf and whole plant [illegible] days post emergence and the third leaf below the stalk from the [illegible] leaf at bloom are shown in Tables 3-10, 3-11, and 3-12. The [illegible] mature leaf concentrations of N, Ca, and [illegible] increased to the 5[illegible] ha^{-1} rate with IVOMD increasing to the 168 kg N ha^{-1} (Table 3-10).

Nitrogen fertilizer rates affected the concentration of [illegible] Mn, Cu, Zn, OM, and IVOMD when the whole plant at 40 days post emergence was analyzed (Table 3-11). Nitrogen, K, and OM increased [illegible] response to N fertilizer when the third leaf below the flag leaf was sampled at sorghum bloom (Table 3-12).

Lockman (1972a, b, c) reported that Mg sufficiency values ranged from 0.20 to 0.50 dag kg^{-1} for third-leaf samples of grain sorghum taken at the bloom stage. Data in Gallaher et al. (1975) indicate that grain sorghum will respond to Mg fertilization when fourth leaf tissue at the late pollination stage drops below 0.2 dag kg^{-1}. The actual Mg sufficiency level for grain sorghum grown under similar conditions may be somewhat greater than 0.2 dag kg^{-1} because both yield and Mg concentration had not leveled off at the highest rate of Mg fertilization.

[illegible]

[illegible]	[illegible]	[illegible]
Location 1		
[illegible]	[illegible]	[illegible]
Stal[illegible]	[illegible]	[illegible]
Whole plant yield [illegible]	Y = 1895 + 1059X	0.74
Grain/stover	Y = 38 + .05X	0.20
N conc. grain [illegible]	Y = 1.36 + .196X	0.70
N content grain [illegible]	Y = 2.06 + 11.36X	0.78
N conc. stalks [illegible]	Y = .38 + .12X	0.71
N content stalks [illegible]	Y = -.01 + 8.7X	0.82
IVOMD grain [illegible]	Y = 5.9 - 17.5X + [illegible]	[illegible]
DOM grain [illegible]	Y = [illegible]10 + 257X	[illegible]
IVOMD stalks [illegible]	Y = [illegible] + 3.08X	[illegible]
DOM stalks [illegible]	Y = [illegible] + [illegible]X	[illegible]
Location 2		
Grain yield kg ha^{-1}	Y = 66 + 305X	0.49
Stalk yield kg ha^{-1}	Y = 2011 + 977X	0.60
Whole plant yield kg ha^{-1}	Y = 2097 + 1282X	0.62
Grain/stover	Y = .10 + .03X	0.25
N conc. grain dag kg^{-1}	Y = 1.30 + .19X	0.48
N content grain kg ha^{-1}	Y = -2.9 + 7.5X	0.60
N conc. stalks dag kg^{-1}	Y = .43 + .10X	0.47
N content stalks kg ha^{-1}	Y = 1.3 + 12.1X	0.78
IVOMD grain dag kg^{-1}	Y = -10.5 + 1.8X	0.25
DOM grain kg ha^{-1}	Y = 36.7 + 208X	0.53
IVOMD stalks dag kg^{-1}	Y = 1.59 + .48X	0.30
DOM stalks kg ha^{-1}	Y = 934 + 598X	0.59

[illegible]

Dependent [illegible]	[illegible]	
Location 3		
Grain yield kg ha^{-1}	$Y = -2098 + 2923X -$ [illegible]	[illegible]
Stalk yield kg ha^{-1}	$Y = -1570 + 2612X - 30$[illegible]	[illegible]
Whole plant yield kg ha^{-1}	$Y = -3668 + 5536X - 787X$	[illegible]
Grain/stover	$Y = .46 + .31X - .05X^2$	[illegible]
N conc. grain dag kg^{-1}	$Y = .84 + .19X$	[illegible]
N content grain kg ha^{-1}	$Y = 3.7 + 8.6X$	[illegible]
N conc. stalks dag kg^{-1}	$Y = 1.06 - .59X + .12X^2$	[illegible]
N content stalks kg ha^{-1}	$Y =$ [illegible]$.6 + 5.3X$	[illegible]
IVOMD grain dag kg^{-1}	—	—
DOM grain kg ha^{-1}	—	—
IVOMD stalks dag kg^{-1}	—	—
DOM stalks kg ha^{-1}	—	—

*X = Coded N rate, X [illegible] = 56, 3 = 112, 4 = 168, and 5 = 224 kg N ha^{-1}).

[illegible]

[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
kg ha^{-1}												
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	2.74	2.58	0.24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	2.99	2.98	0.26	0.22	1.81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	2.90	3.25	0.25	0.23	1.71	2.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	2.93	3.30	0.21	0.25	1.68	1.82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	52	23	NS*	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

N Treatment	Mn		[illegible]		[illegible]		[illegible]		[illegible]	
	Location		[illegible]		[illegible]		[illegible]		[illegible]	
	1	[illegible]	1	2	1	[illegible]	[illegible]	[illegible]	1	[illegible]
kg ha^{-1}	mg kg^{-1}						dag kg^{-1}			
0	34.25	31.00	3.5	6.5	3.00	25.00	88.00	91.28	50.48	[illegible]
56	54.25	31.25	5.0	5.0	17.00	21.25	90.38	90.70	61.65	[illegible]
112	45.75	31.25	4.0	6.0	21.75	23.00	90.75	91.03	64.38	[illegible]
168	41.50	33.75	3.5	6.3	15.00	24.25	91.75	90.73	59.50	[illegible]
224	36.50	34.75	4.0	6.5	16.50	27.50	91.88	[illegible]	[illegible]	[illegible]
LSD .05	NS	NS	NS	1.0	5	5	[illegible]	[illegible]	[illegible]	[illegible]

*NS = Not significant at the 0.0[illegible] level of probability.

Table 3.11 Tissue analysis of sorghum whole plant at [illegible] locations

N Treatment	[illegible]		P		[illegible]		[illegible]		[illegible]		[illegible]	
	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
	1	2	1	2	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	1	[illegible]
kg ha^{-1}					dag kg^{-1}						[illegible]	
0	1.54	1.90	0.25	0.32	1.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	2.36	2.08	0.25	0.30	[illegible]	[illegible]	[illegible]	0.25	0.30	[illegible]	[illegible]	[illegible]
112	3.03	2.52	0.35	0.36	[illegible]	[illegible]	[illegible]	0.31	0.38	[illegible]	[illegible]	[illegible]
168	3.02	2.66	0.31	0.31	1.59	1.68	0.32	0.29	0.39	0.30	[illegible]	[illegible]
224	3.10	2.76	0.33	0.32	1.57	1.63	0.35	0.29	0.39	0.29	[illegible]	[illegible]
LSD .05	.22	.19	.07	NS*	.09	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]. [illegible]

Treatment	Mn		[illegible]		[illegible]		[illegible]		[illegible]	
	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
	1	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}	mg kg^{-1}						dag kg^{-1}			
0	22.25	23.25	4.75	6.00	13.50	19.25	92.00	96.38	[illegible]	[illegible]
56	28.75	28.50	5.25	5.25	15.50	23.00	91.30	96.65	[illegible]	[illegible]
112	35.25	34.00	6.00	6.75	17.25	26.25	90.93	96.50	[illegible]	[illegible]
168	36.00	33.75	5.50	6.25	19.75	[illegible]	93.38	[illegible]	[illegible]	[illegible]
224	38.50	36.25	6.00	7.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	5	6	NS	1.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

^{a}NS = not significant at the 0.05 level [illegible]

Table 3.12 Tissue anal[illegible] locations.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	2.81	2.27	0.24	0.20	1.94	3.15	0.31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	2.63	2.49	0.24	0.24	1.99	3.05	0.40	[illegible]	[illegible]	0.30	[illegible]	[illegible]
224	2.85	2.69	0.23	0.20	2.55	2.85	0.33	[illegible]	[illegible]	0.31	[illegible]	[illegible]
LSD .05	32	30	NS*	[illegible]	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}	mg kg^{-1}						[illegible]			
0	57.25	43.00	5.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	58.[illegible]	[illegible]
56	58.50	42.25	4.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	67.00	39.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	65.00	43.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	69.75	45.25	4.50	5.25	14.50	30.25	95.5[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	NS	NS	NS	NS	NS	NS	NS	0.61	NS	[illegible]

*NS = Not significant at the 0.05 level of probability [illegible] kg^{-1}, [illegible] to 0.24 d[illegible] 2.08 dag kg^{-1}, [illegible] the youngest mature [illegible] days post emergence was used as the diagnostic sample ([illegible]). Potassium gradually decreased as rates of N fertilizer increased. Nitrogen, P, and K concentration ranged from 1.72 to 2.93 dag kg^{-1}, 0.[illegible] to 0.32 dag kg^{-1}, 1.60 to 1.73 dag kg^{-1}, respectively, when the whole plant at 40 days was used as the diagnostic sample (Table 3-11). As with the leaf sample, K concentration decreased with increasing N fertilizer. Nitrogen, P, and K concentration ranged from 1.6[illegible] to 1.77 dag kg^{-1}, 0.22 to 0.30 dag kg^{-1}, and 2.74 to 3.00 dag kg^{-1}, respectively, when the third leaf below the flag at bloom was used as the diagnostic sample (Table 3-12). [illegible] and K concentration decreased with increasing N fertilization.

Critical nutrient levels (CNL) for grain sorghum are not well established, but Lockman (1972a, b, c) stated that leaf N in grain sorghum at several vegetative stages was highly correlated with final grain yields. He further suggested that deficiency levels for the third leaf below the flag at bloom were in the order of 2.5 to 3.2 dag kg^{-1} N. Sorghum grain yields decreased as leaf N at full bloom dropped below 2 dag kg^{-1}. Leaf N at this stage accounted for about 63% of the variation in grain yields.

Eylands (1984) found that applied N increased nutrient concentrations of P, Ca, Mg, Fe, Zn, Mn, and Cu, and decreased K in the diagnostic leaf of grain sorghum when following either crimson clover (Trifolium incarnatum L.) or lupine (Lupinus angustifolius L.). Grain N and whole plant N content of grain sorghum also increased with applied N, as did grain nutrient levels exceeding 100 kg ha^{-1}, correlating to [illegible] higher. [illegible] of grain sorghum [illegible]

[illegible] to compare these [illegible] sampling [illegible] grain, stalk, and whole plant yields [illegible] for locations 1 and 2 [illegible] Table [illegible] yield [illegible] Appendix Tables [illegible] predicting grain yield [illegible] was positively [illegible] to final grain [illegible] sampling techniques [illegible] for the whole plant [illegible] emergence to give the [illegible] correlations (Table [illegible]

[illegible] the youngest mature [illegible] days was sampled [illegible] DM, and IVOMD were positively correlated to grain yield [illegible]. Only N and IVOMD were positively correlated to stalk or whole plant DM yields with this sampling technique. When the whole plant was sampled at 40 days N, Ca, Mg, Fe, Mn, Cu, and IVOMD were all positively correlated to final grain yield and N, Ca, Mg, Mn, Zn, and IVOMD were positively correlated to stalk and whole plant DM yields. Potassium was negatively correlated with grain yield while plant DM concentration was negatively correlated with grain, stalk, and whole plant DM yield.

When the third leaf below the flag leaf at bloom was sampled, N was the only nutrient positively correlated with grain yield at both locations (Table 3-13). Nitrogen and DM were positively correlated with stalk yield with P negatively correlated. Nitrogen, Ca, Mg, and DM were positively correlated with whole plant DM yield while P was negatively correlated. The lack of P being correlated to grain yield

[illegible]

	Youngest mature leaf at 40 days		Whole plant at 40 days		[illegible]	
	Location		Location		[illegible]	
	1	2	1	2	1	2
[illegible]	[illegible] kg ha^{-1}					
[illegible]	0.51	0.64	[illegible]	0.73	[illegible]	[illegible]
[illegible]	[illegible]	NS	[illegible]	NS	[illegible]	[illegible]
[illegible]	[illegible]	NS	[illegible]	-0.38	[illegible]	[illegible]
Ca	[illegible]	0.39	0.73	0.72	NS	[illegible]
Mg	[illegible]	NS	[illegible]	0.72	NS	[illegible]
Fe	[illegible]	NS	0.73	0.55	NS	[illegible]
Mn	[illegible]	0.40	0.55	0.44	NS	[illegible]
Cu	[illegible]	NS	0.50	0.37	-0.46	[illegible]
Zn	-0.59	-0.41	0.48	NS	-0.41	[illegible]
DM	0.45	-0.54	-0.46	-0.40	NS	[illegible]
OM	0.57	NS	NS	NS	0.64	[illegible]
IVOMD	0.65	0.52	0.39	0.72	NS	[illegible]
	stalks kg ha^{-1}					
N	0.49	0.80	0.89	0.74	0.67	[illegible]
P	NS	NS	0.54	NS	-0.58	[illegible]
K	NS	-0.82	-0.71	NS	NS	NS
Ca	0.48	NS	0.84	0.70	NS	NS
Mg	0.46	NS	0.87	0.59	0.42	NS
Fe	0.37	0.43	0.58	NS	NS	NS
Mn	NS	NS	0.64	0.38	0.42	NS
Cu	NS	NS	0.58	NS	-0.44	NS
Zn	-0.42	NS	0.58	0.47	-0.49	NS
DM	0.48	0.41	-0.50	-0.62	NS	NS
OM	0.61	NS	NS	NS	0.64	0.55
IVOMD	0.74	0.40	0.66	0.73	NS	NS

[illegible] (continued)

	Youngest mature leaf at 40 days		Whole plant at 40 days		[illegible]	
	Location		Location		[illegible]	
	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	-- whole plant [illegible] --					
[illegible]	[illegible]	0.81	0.89	0.74	[illegible]	[illegible]
[illegible]	[illegible]	NS	0.51	NS	[illegible]	[illegible]
[illegible]	[illegible]	-0.56	-0.68	NS	[illegible]	[illegible]
[illegible]	[illegible]	NS	0.83	0.75	[illegible]	[illegible]
[illegible]	[illegible]	NS	0.87	0.63	[illegible]	[illegible]
Fe	[illegible]	0.45	0.52	NS	[illegible]	[illegible]
Mn	[illegible]	NS	0.63	0.42	[illegible]	[illegible]
Cu	[illegible]	NS	0.58	NS	[illegible]	[illegible]
Zn	[illegible]	NS	0.56	0.42	0.48	[illegible]
DM	[illegible]	0.47	-0.51	-0.61	NS	[illegible]
OM	[illegible]	NS	NS	NS	0.68	[illegible]
IVOMD	[illegible]	0.45	0.57	0.76	NS	[illegible]

*NS = Not significant at the 0.05 level of probability

[illegible] and Cu [illegible] generally [illegible] creases with [illegible] widely due to location, soil types, and hybrids (Frib[illegible] Lockman (1972b) found that Cu levels were not well correlated with yields Higher Cu levels were noted with later samples in a dry year. Iron levels in grain sorghum generally were not well correlated with yield (Lockman, 1972b) However, in the current study Fe concentrations in all three sampling techniques were moderately to highly correlated with grain, stalk, and whole plant DM yields

Conclusions

Grain sorghum DM yield for grain and whole plant increased at the 56 kg N ha^{-1} rate at two locations and to the 112 kg N ha^{-1} rate for the third location. Residue DM yield increased to the 112 kg N ha^{-1} rate at all locations. Sorghum webworm at location 2 and moisture deficits at location 1 had a greater effect on grain yields than residue yields. As with corn, the 224 kg N ha^{-1} fertilizer rate reduced yields where moisture was deficient. Grain yield and whole plant yield averaged over the three locations were 560 and 342% higher than the control at the 168 kg N ha^{-1} rate, respectively. Grain N concentration increased to the 112 kg N ha^{-1} rate at location 1 and to the 224 kg N ha^{-1} rate at locations 2 and 3. The grain concentration of P, K, Ca, Mg, Fe, Mn, Cu, and Zn were not affected by N fertilizer at any location. Iron concentration did show increases to 168 kg N ha^{-1} rate only at location 1. The concentration of nutrients in sorghum stalks increased with increasing rates of N fertilizer.

[illegible] 56, 112, 168, and [illegible]. Efficiencies [illegible] uptake were 43, [illegible] 168, and 224 [illegible] respectively.

It appears that [illegible] nutrients, particularly N in the youngest [illegible] at 40 days post emergence, whole plant at 40 days, and third leaf below the flag leaf at bloom can all be used as good predictors of grain yield and whole plant DM. Sampling of whole plants at 40 days gave higher correlations for N and Ca as predictors than did the leaf analyses to predict final yield of grain, residue, and whole plant DM yields.

CHAPTER 4
[illegible]LD AND CHEMICAL COMP[illegible] [illegible]HIAGRASS AS INFLUENCED [illegible] [illegible] SOURCE, AND APPLICATION [illegible]

Introduction

There [illegible] million [illegible] acres of improved [illegible] (*Paspalum* [illegible]*tatum* [illegible]) in the southeastern [illegible] States. This pasture [illegible] maintained and provides [illegible] cattle producers with an [illegible] to let cattle graze during late spring, summer, and [illegible] productivity and quality of bahiagrass can be improved [illegible] application of N fertilizer which has been studied by [illegible] researchers (Beaty et al., 1960, 1977, Blue, 1966, 1972, 1974, [illegible] et al., 1977). However, with low beef prices and increased [illegible] for N fertilizer much of this pasture is never fertilized adequately for good forage quality and productivity. Nitrogen is the largest and most expensive component of bahiagrass fertilization. While anhydrous ammonia (NH_3) is one of the least expensive sources of available N, research in the 1950s conducted by Blue and Eno (1954) and later (Blue, 1984) indicated that up to 40% of the applied N could be lost due to volatilization of ammonia.

This loss was dependent upon the cation exchange capacity (CEC) of the soil, soil temperature, moisture, pH of the soil, and spacing of injectors. Since the 1950s new and improved application equipment is in use that may make the utilization of anhydrous ammonia more [illegible] studies have [illegible] sources for fer[illegible] significant response [illegible] increasing N rates [illegible] content of forage ([illegible], 1960, 1963, [illegible], 1980, [illegible], 1974). However, [illegible] limited information is available [illegible] of bahiagrass [illegible] anhydrous ammonia as a fertilizer [illegible] efficiency of using anhydrous ammonia in comparison [illegible] N in crops has been studied by many investigators. [illegible] (1964) summarized the results of many investi[illegible] tiveness of various sources of N on several crops [illegible] anhydrous ammonia. They concluded that anhydrous [illegible] most other N sources.

The results of most experiments on forage indicate th[illegible] the year of application, yields are somewhat greater from gra[illegible] fertilized with ammonium nitrate (NH_4NO_3) in split applicati[illegible] with anhydrous ammonia applied in one application at rates of [illegible] 324 kg N ha^{-1} (Tesar, 1974). Burton and Jackson (1962) conducted trials on 'Coastal' bermudagrass (Cynodon dactylon L.) for 5 years utilizing anhydrous ammonia as one source of N. The anhydrous ammonia was applied in 40 cm rows with a chisel-type knife. Total yields were greater for ammonium nitrate fertilized grass at the 112 and 224 kg ha^{-1} rates of N if fertilizer was applied in split applications. When the fertilizer was applied in one application in mid-March, anhydrous ammonia was equal to ammonium nitrate in effectiveness. Hill and Tucker (1968) found yields equal for all sources and all clippings [illegible] N applic[illegible] [illegible] produced [illegible] succeeding cl[illegible] [illegible] soil burn from [illegible] Reducing [illegible] spacing tended to increase [illegible] decrease[illegible] and increased the NH_3 efficiency [illegible] rates of N [illegible]

Lechtenberg et al. (1974)[illegible] ammonia [illegible] bromegrass (Bromus inermis [illegible]) found that it was [illegible]tive in increasing animal [illegible] per hectare as was [illegible] at the same application rate.

[illegible] objective of this study was [illegible] the effect [illegible] ammonia versus ammonium [illegible] sources of N on the [illegible] chemical composition of bahiagrass forage.

Materials and Methods

Experiments were conducted at two locations during 1983 and one location during 1984. All locations were in Levy County, Florida latitude 29°30' North, longitude 82°30' West. Five rates of N (0, 56, 112, 168, and 224 kg N ha^{-1}) were whole plot treatments within which each of the split plot sources of N (ammonium nitrate and anhydrous ammonia) and were randomized and replicated four times (Table 4-1). Treatments were applied during 1983 on June 8 at location 1 and on June 11 at location 2. Location 3 received all treatments on May 29, 1984.

All locations had been in bahiagrass sod for 15 years. Location 1 was a Kershaw fine sand (thermic, uncoated, typic Quartzipsamment), an excessively drained soil. Locations 2 and 3 were on a Candler series

Table 1. Statistical analysis model used for bahiagrass data. Split-plot design.

Source	df	
Total	39	(rTS-1)
Total whole plots	19	(rT-1)
Replication (r)	3	(r-1)
Whole plot (T)	4	(T-1)
Error a	12	(r-1)(T-1)
Total split plot	20	(rTS-1) - (rT-1)
Split source (S)	1	(S-1)
Whole plot x split source	4	(T-1)(S-1)
Error b	15	

[illegible]

Split [illegible] into the bahiagrass [illegible] a DMI "Sod Booster" [illegible] developed by DMI Inc., Goodfield, Illinois. The applic[illegible] type unit with nine spring-loaded shanks on 35.5 cm [illegible] adjustable knives and a packer wheel behind each knif[illegible] A-6503 regulator was utilized to regulate the anhydr[illegible]. Ammonium nitrate was broadcast by hand to all plots receiving th[illegible] treatment.

All plots at all locations were fertilized with a broadcast application of 80 kg K ha^{-1}, 25 kg S ha^{-1}, and 12 kg Mg ha^{-1} prior to applying N treatments. Sources of K, S, and Mg were K_2SO_4 $MgSO_4$ (K-Mag) and KCl.

All plots were harvested with a rotary type mower with a grass catching attachment. Clipping height was 2.5 cm. Harvest size was 1 x 7 m with all plots being harvested at 13-week intervals until October of each year when cool temperatures and dry weather severely limited growth. Stolon root samples were obtained by taking three 12.5 cm diameter cores to a depth of 15 cm from each split plot both prior to and following final harvest. Treatment and harvest dates are shown in Table 4-2. These samples were washed thoroughly to remove soil. Both forage and stolon root samples were dried in a forced air oven at 70 C, then ground in a Wiley mill through a 1 mm stainless steel screen. Soil samples were taken following final harvest at depths of 0-20 and 20-40 cm. Soil sample results are shown in Appendix Table C-1. Chemical analyses of soil and plant tissue was

[illegible]

[illegible]		[illegible]	[illegible]	[illegible]
1	Stolon samples	[illegible]	[illegible]	5/16
2	N treatments	[illegible]	[illegible]	5/20
3	Forage harvest	[illegible]	[illegible]	[illegible]
	Forage harvest	[illegible]	[illegible]23	[illegible]
	Forage harvest	8/1[illegible]	8/17	8/2
	Forage harvest	8/31	[illegible]	8/23
	Forage harvest	[illegible]	[illegible]	[illegible]
4	Stolon samples	10/1	[illegible]	[illegible]
5	Soil samples	10/3	[illegible]	[illegible]

[illegible]

[illegible] analysis was performed according to [illegible]

[illegible] each location [illegible] at each rate [illegible] kg increment of N, and [illegible] (kg DM produced kg^{-1} N applied).

Recovery of applied N was calculated by the following [illegible]:

$$\frac{\text{N uptake (treatment)} - \text{N uptake (control)} \times 100}{\text{annual N application (treatment)}}$$ [illegible]

The cost of anhydrous ammonia was calculated at \$14.00 [illegible] application plus \$.38 kg^{-1} material (82% N) applied which computes to a cost of \$.32 kg^{-1} of applied N plus \$14.00 ha^{-1} at each rate of N. The cost of ammonium nitrate was calculated at \$.215 kg^{-1} of material (34% N) or \$.63 kg^{-1} of N.

Results and Discussion

No differences in total seasonal dry matter (DM) yield were found between sources of N except at location 1 at the 112 kg N ha^{-1} rate in favor of anhydrous ammonia, and at the 168 and 224 kg N ha^{-1} rates for ammonium nitrate (Table 4-3). There were also differences between sources at individual harvest dates (Table 4-4) with the last harvest at location 1 and the first harvest at location 3, where yield was 21% greater for anhydrous ammonia.

[illegible] Influence [illegible] concentration [illegible]

[illegible]	Location [illegible]		[illegible]		[illegible]		
	NH_3	NH_4NO_3	NH_3	NH_4NO_3	NH_3	NH_4NO_3	
[illegible]	DM kg ha^{-1}						
[illegible]	2350	2600	2500	2340	2340	1830	[illegible]
[illegible]	5540	5840	4830	4800	3650	3120	[illegible]
[illegible]	6980	6170	5230	5560	3240	3750	[illegible]
[illegible]	6690	7250	6260	6200	4550	3880	[illegible]
[illegible]	6850	7350	7110	6660	5330	5170	[illegible]
LSD .0[illegible]	700		750		1000		
LSD .05 [illegible]	470		NS*		NS		
	N dag kg^{-1}						
0	1.46	1.27	1.03	1.16	1.40	1.40	1.[illegible]
56	1.43	1.45	1.13	1.35	1.39	1.59	[illegible]
112	1.67	1.54	1.3[illegible]	1.44	1.52	1.72	1.[illegible]
168	1.78	1.70	1.51	1.46	1.72	1.82	1.6[illegible]
224	1.81	1.93	1.51	1.35	1.82	1.83	1.[illegible]
LSD .05 Rate	16		15		13		
LSD .05 Source	NS		06		05		
	IVOMD dag kg^{-1}						
0	35	38	27	30	--	--	3[illegible]
[illegible]6	38	41	28	32	-	--	35
11[illegible]	37	41	33	33	--	--	36
[illegible]	38	42	31	33	--	--	36
[illegible]4	39	46	34	38	--	--	3[illegible]
LSD .05 Rate	2		2				
LSD .05 Source	2		2				

[illegible]

[illegible]	[illegible]		[illegible]		[illegible]		[illegible]
	NH_3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
$kg\ ha^{-1}$	[illegible]						
0	[illegible]	671	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	638	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	573	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	[illegible]	602	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224	[illegible]	581	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05 Rate	NS		[illegible]		[illegible]		
LSD .05 Source	NS		[illegible]		[illegible]		
	--- Mn mg kg^{-1} ---						
0	84	84	92	90	109	[illegible]	[illegible]
56	85	80	81	83	97	[illegible]	[illegible]
112	85	86	77	80	96	91	[illegible]
168	85	83	76	75	92	91	86
224	84	92	81	79	97	100	87
LSD .05 Rate	NS		NS		NS		
LSD .05 Source	NS		NS		NS		
	--- Cu mg kg^{-1} ---						
0	6	5	5	5	5	5	5
56	5	5	5	5	5	5	5
112	6	6	6	6	5	6	6
168	6	6	6	5	6	6	6
224	6	6	6	6	6	6	6
LSD .05 Rate	3		5		40		
LSD .05 Source	NS		NS		NS		

Table [illegible]. Continued.

Rate	[illegible]		[illegible]		[illegible]		[illegible]
	NH_3	NH_4NO_3	NH_3	NH_4NO_3	NH_3	NH_4NO_3	
kg ha^{-1}	Zn mg kg^{-1}						
0	9	27	57	58	50	50	45
56	3	24	67	39	39	36	38
112	[illegible]	25	63	43	34	36	37
168	3	28	42	45	36	37	35
224	[illegible]	26	63	45	37	38	38
LSD .05 Rate	NS		11		9		
LSD .05 Source	NS		NS		NS		
	P Mg ha^{-1}						
0	[illegible]	0.18	0.13	0.13	0.17	0.17	0.16
56	[illegible]	0.22	0.12	0.14	0.16	0.17	0.17
112	[illegible]	0.19	0.14	0.16	0.18	0.19	0.18
168	[illegible]	0.19	0.15	0.17	0.18	0.20	0.18
224	0.19	0.22	0.16	0.16	0.19	0.20	0.19
LSD .05 Rate	NS		.01		.01		
LSD .05 Source	.01		.01		.01		
	P kg ha^{-1}						
0	4	5	3	3	4	3	4
56	10	4	6	7	6	6	8
112	10	13	8	9	6	7	9
168	1[illegible]	14	9	11	9	8	10
224	13	16	11	10	10	11	12
LSD .05 Rate	2.2		1.4		2.0		
LSD .05 Source	1.5		NS		NS		

[illegible]

[illegible]	[illegible]	[illegible]	NH_3	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.4[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]47	0.39	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.41	0.37	[illegible]	[illegible]
LSD [illegible] Rate	NS		03		03		
LSD [illegible] Source	NS		NS		NS		
	Ca kg ha^{-1}						
[illegible]	13	12	10	9	10	[illegible]	10
[illegible]	22	24	18	19	15	13	18
[illegible]	29	28	24	23	13	13	22
[illegible]	27	28	18	20	17	16	21
[illegible]	30	30	24	26	20	20	25
LSD 0.05 Rate	2.0		3.0		3.4		
LSD 0.05 Source	NS		NS		NS		

NS Not significant at the 0.05 level of probability.

Table 4 4 Bahiagrass dry matter yield as affected by source of nitro[illegible]

Harvest Number*	Nitrogen Source					
	Location 1		[illegible]		[illegible]	
	NH_3	NH_4NO_3	NH_3	NH_4NO_3	NH_3	NH_4NO_3
	-------- kg ha^{-1} --------					
1	1130	1150 NS**	[illegible]	[illegible]	[illegible]	[illegible]
2	1200	1390 NS	1180	[illegible]	[illegible]	[illegible]
3	2120	2270 NS	2100	2080 NS	[illegible]	[illegible]
4	850	820 NS	720	690 NS	[illegible]	730 NS
5	380	300 S	---	---	390	350 [illegible]

*Harvest Number = 21 days between harvests

**NS = Not significant at the 0 05 level of pr[illegible]

***S = Significant at the 0.05 level of probabil[illegible]

[illegible] uptake [illegible] and [illegible] (1962) who found a greater [illegible] effect [illegible] after application favoring anhydrous ammonia over ammonium [illegible] used for bermudagrass fertilization. Hill and Tucker (1968) [illegible] similar results at higher rates of N ha^{-1} and attributed low [illegible] the first harvest to sod burn and escaping ammonia. Likewise, [illegible] (1969), and Tesar et al. (1972) measured the residual effects [illegible] anhydrous ammonia in the year following fertilization and found greater yields from grass fertilized with anhydrous ammonia than with ammonium nitrate. Schoor and Tesar (1977) noted greater carryover of N after a dry year at rates of 45 and 90 kg N ha^{-1} from ammonium nitrate. In most studies on tropical forages, anhydrous ammonia consistently gave the lowest yields in the first cutting and higher yields in subsequent cuttings.

Dry matter yield responded to the 112, 224, and 168 kg N ha^{-1} rate for anhydrous ammonia and to the 168, 112, and 224 kg N ha^{-1} rate for ammonium nitrate at locations 1, 2, and 3, respectively. The overall mean DM yields over all sources and rates ranged from 2320 kg ha^{-1} for 0 N ha^{-1} to 6410 kg ha^{-1} at 224 kg N ha^{-1} (Table 4-3). There were interactions between location and rate when data were combined. The range in yields at 2.5 cm clipping height is consistent with that found by Blue (1966, 1977, 1980, 1983) and Beaty et al. (1976, 1977). Nitrogen concentration varied due to source at locations 2 and 3 with a greater concentration due to ammonium nitrate. In general, N concentration increased with increasing rate of N for both anhydrous ammonia or among [illegible] (Table [illegible]). [illegible] factors, including soil [illegible] maturity, yield, pasture management, [illegible] (McDowell [illegible] 1955).

[illegible] concentrations were sli[illegible] than those [illegible] (1971) over 6 years of N fertili[illegible] sources of N.

The IVOMD responded to increasing rates of N and was higher with ammonium nitrate at most rates (Table 4-3). The IVOMD concentrations ranged from 32 to 39 dag kg^{-1} when averaged over sources, locations, and N rates. These values are lower than those found by other researchers (Moore et al., 1970, Prates et al., 1974, Ruelke and Prine, 1971). Some researchers have reported increases in digestibility of N fertilized forage while others have reported no difference due to the application of N fertilizers (Ford and Williams, 1973). Waite (1970) noted an increase in the IVOMD of orchardgrass (*Dactylis glomerata* L.) and ryegrass (*Lolium multiflorum* Lam.) with N fertilization. Fribourg et al. (1971) noted an increase in IVOMD of bermudagrass from 37 to 46% as N applied increased from 0 to 800 kg ha^{-1}. Others have shown no difference due to N rate (Ruelke and Prine, 1971, Webster, 1965). Nitrogen fertilizer stimulates rapid growth which possibly causes lower levels of soluble and structural carbohydrates and a higher digestibility (Waite, 1970). Stanley et al. (1977) found that when bahiagrass was fertilized with 0 to 336 kg N ha^{-1} and clipped to height from 0-12.5 cm above the stolons that cell wall constituents of the forage ranged from 70-72% and were not influenced by N fertilization

[illegible]

trichoglum [illegible] increased [illegible] percentage of [illegible] utilizing [illegible] fertilized with anhydrous ammonia [illegible] ha^{-1} found that anhydrous ammonia [illegible] ammonium nitrate in increasing animal production per [illegible] the level of N fertilization had no effect on percent IVOMD.

During 1983 and 1984 [illegible] temperatures were higher than normal and less rainfall than average occurred during the harvesting period June through October. Henderson and Robinson (1982b) studied environmental influences on yield and in vitro true digestibility (IVTD) of warm season perennial grasses. They found that DM yield increased with increasing photon flux density and temperature. In all grasses studied including 'Pensacola' bahiagrass IVOMD consistently decreased as temperature increased.

Henderson and Robinson (1982a) found negative correlations between IVOMD and concentrations of acid detergent fiber (ADF), cellulose, permanganate lignin (Lig), and silica. In a review of the literature, Cooper and Tainton (1968) stated that growth rates of most tropical grasses increased with temperature from 30 to 35 C and light intensity to 60,000 lux or higher. Conditions favoring maximum growth rates have frequently resulted in lower forage quality. High temperatures during rapid growth periods have been related to increased proportions of stems, increased fiber concentrations, decreased water soluble carbohydrate concentrations, and reduced herbage digestibility of tropical [illegible] [illegible] Langdale (1983) [illegible] 'Pensacola' bahiagrass [illegible] range of 1.5 - 1.7% [illegible] these levels were reached at [illegible] highest N rates of 168 and 224 kg N ha^{-1} in the current study [illegible]. Brown and Ashley (1974) reviewed the literature pertaining to [illegible] metabolism and carbohydrate reserves in plants and found that N fertilization, particularly of grasses, increases N content which is associated with growth resulting from high N rates and they concluded [illegible] reserves would be limited under such conditions.

[illegible] and Brown (1977) found evidence to indicate that photosynthate is not utilized for new growth or metabolism when N is deficient but accumulates in bundle sheath cells in the form of starch. More starch in the leaves of N deficient leaves of bahiagrass is in agreement that N stimulates the translocation of assimilates from leaves and their utilization with a corresponding reduction in carbohydrate accumulation in the leaves. It has been shown that age of the forage has a direct effect upon digestibility (Moore et al., 1970, Prates et al., 1974). A possibility for the greater digestibility from ammonium nitrate could be due to destruction of bahiagrass stolons during the injection process of NH_3 where more soluble carbohydrates would be utilized to rebuild cells and structural carbohydrates in the stoloniferous root systems (Sampaio and Beaty, 1976). Insufficient rainfall and increased temperatures apparently influenced all parameters measured over all locations and harvest dates (Table 4-5). This effect has been reported in other N rate studies as noted previously.

[illegible] bahiagrass [illegible] conducted during 1983-84 at [illegible]

Date	1983		1984
	Location 1	Location [illegible]	Location [illegible]
	no.		
5/15			
5/20			
5/25			[illegible]
5/30			[illegible]
6/5			
6/10	10		
6/15			[illegible]
6/20	6	58	[illegible]
6/25	[illegible]	[illegible]	
6/30	101		[illegible]
7/5	[illegible]	114	[illegible]
7/10	13		[illegible]
7/15			
7/20			
7/25	20	38	[illegible]
7/30	19	46	[illegible]
8/5	33		[illegible]
8/10			
8/15			[illegible]
8/20	76	101	[illegible]
8/25		6	
8/30			
9/5			
9/10			
9/15	13	13	

[illegible] among [illegible] in studies [illegible] (1985) [illegible] bahiagrass hay were likely to be deficient in P, [illegible] Zn at all stages of maturity. Mean concentrations of all elements except K at 0 N rate, or P and Cu at all rates of N in forage DM would meet the National Research Council (NRC) requirements of a 450 kg body weight beef cow of average milking ability (Table 4-6).

Total kg P ha^{-1} responded due to source only at location 1 at the 56, 168, and 224 kg N ha^{-1} rates. Phosphorus increased with rate and responded to the 56 to 224 kg ha^{-1} rates depending on location and N sources. Reid and Jung (1965) found that P fertilized tall fescue had a higher content of soluble carbohydrate and a higher IVOMD.

Iron concentration also varied due to source and rate with concentrations being higher in the anhydrous ammonia treated forage at the 56 and 0 kg N ha^{-1} rates at locations 2 and 3, respectively (Table 4-3). This could possibly be due to contamination of samples with soil as the Fe concentration was highest at the 0 rate and decreased through 168 kg N ha^{-1} when locations were averaged. Calcium, Mn, Cu, and Zn concentrations were changed from N application but not by source of N (Table 4-3).

No differences due to sources of N were found for OM, N, K, or Mg contents or K or Mg concentrations in forage (Table 4-7). The N content increased with the 168 kg N ha^{-1} rate at location 1 and to the 224 kg N ha^{-1} rate at locations 2 and 3.

The bahiagrass stoloniferous root system and its response to N rates and sources have been studied by several researchers (Beaty

[illegible]

[illegible]	[illegible]	[illegible]				
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]				
[illegible]	[illegible]	0.16	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.62	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Magnesium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]				
Iron	[illegible]	777	[illegible]	[illegible]	[illegible]	[illegible]
Manganese	40	94	[illegible]	[illegible]	[illegible]	[illegible]
Copper	8	5	5	[illegible]	[illegible]	[illegible]
Zinc	30	45	38	[illegible]	[illegible]	38

*Suggested value of requirement (NRC, 1984)

**Suggested value for beef cows with average milking [illegible] body-weight of 450 kg (NRC, 1984)

[illegible]

N Rate	[illegible]	[illegible]	[illegible]	Average
kg N ha^{-1}	---------- [illegible] ha^{-1} ----------			
0	1990	[illegible]	[illegible]	1360
56	4280	[illegible]	[illegible]	3370
112	5080	[illegible]	2850	4067
168	5360	[illegible]	3580	4730
224	5240	[illegible]	4450	5150
LSD 05	350	600	700	
	---------- N kg ha^{-1} ----------			
0	30	30	30	30
56	80	60	50	60
112	100	80	60	80
168	120	80	80	90
224	120	100	100	110
LSD 05	10	10	20	
	---------- K dag ha^{-1} ----------			
0	0 70	0 60	0 55	0 62
56	0 79	0 82	0 57	0 73
112	0.86	0 91	0.69	0 81
168	0 95	0 95	0 65	0 86
224	0 94	0 96	0 75	0 88
LSD .05	.08	08	.08	

Table [illegible] (continued)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg N ha^{-1}		K kg ha^{-1}		
0	20	20	10	[illegible]
56	50	40	20	[illegible]
112	60	50	20	[illegible]
168	70	60	30	[illegible]
224	70	70	40	[illegible]
LSD .05	7	8	8	
		Mg dag kg^{-1}		
0	0.28	0.20	0.21	[illegible]
56	0.27	0.20	0.20	[illegible]
112	0.30	0.22	0.22	[illegible]
168	0.30	0.22	0.24	[illegible]
224	0.33	0.24	0.24	[illegible]
LSD .05	0.03	0.02	0.01	
		Mg kg ha^{-1}		
0	7	5	4	[illegible]
56	16	10	7	11
112	21	12	8	14
168	22	14	10	15
224	23	17	13	16
LSD .05	2	2	2	

---

*Total of all cuttings at each location.

[illegible]

[illegible] IVOMD studies indicated 58% digestibility of this material. Blue ([illegible]) and Blue and Graetz (1977) found that the stoloniferous root [illegible] and that N concentration ranged from 0.36 to 1.02 [illegible] to 224 kg N ha^{-1} applications, respectively, and varied [illegible] the number of N applications and sources.

In the current study there were no differences due to N sources [illegible] the nutrients measured except for P. Phosphorus increased [illegible] nitrate than to anhydrous ammonia at locations 1 and 3 (Table 4-8). Yield and concentration of DM, OM, IVOMD, N, K, Ca, Mg, Fe, Mn, Cu and Zn are found in Tables 4-9 through 4-11. There was no difference due to rate of N for DM yields, IVOMD, and OM ha^{-1}. The nutrient content of [illegible] increased to the 112 kg N ha^{-1} rate only at location 1. The content of K, Ca, and Mg in forage varied due to N rate only at location 3 (Table 4-10). The concentration of nutrients varied among locations with the following results: N concentration responded to 224 kg N ha^{-1} at location 1 and to 56 kg N ha^{-1} at location 2 (Table 4-9). Potassium and Ca responded to N rate with K responding to 112 kg N ha^{-1} at location 1. Calcium concentration decreased with increased rate of N at location 1 and showed no response at the other locations. Iron, Mn, Cu, and Zn concentrations in forage were not different at any location (Table 4-9).

Recovery of applied N is shown in Table 4-12. Recovery tended to follow the same trends as those identified by Beaty et al. (1964) and

Table 4.8. Nutrient content in bahiagrass st[illegible] by rate and [illegible] nitrogen at three locations

Stolons N Rate	Location 1		[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]					
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	.30	.40	[illegible]	[illegible]	[illegible]	[illegible]
224	.30	.30	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05 Rate	20		NS*		[illegible]	
LSD .05 Source	10		NS		[illegible]	

*NS = Not significant at the 0.05 level of probability.

[illegible]

[illegible] N Rate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}			mg kg^{-1}		
Location 1					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	27	07	[illegible]	[illegible]	[illegible]
[illegible]	26	06	[illegible]	10	[illegible]
[illegible]	35	06	[illegible]	[illegible]	[illegible]
LSD .05	07	01	[illegible]	[illegible]	[illegible]
Location 2					
[illegible]	10	05	[illegible]	[illegible]	[illegible]
[illegible]	19	07	[illegible]	[illegible]	[illegible]
[illegible]	13	09	[illegible]	19	10
[illegible]	17	08	[illegible]	20	09
[illegible]	19	06	19	19	11
LSD .05	06	NS	NS	NS	NS
Location 3					
0	45	.10	31	34	15
56	47	09	28	33	13
112	44	08	23	32	13
168	45	08	24	26	12
224	56	09	28	31	20
LSD .05	NS	NS	NS	NS	NS

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			
[illegible]tion 1				
[illegible]	1046	[illegible]	[illegible]	[illegible]
[illegible]	1030	[illegible]	[illegible]	[illegible]
[illegible]	1176	[illegible]	[illegible]	[illegible]
[illegible]	1068	[illegible]	[illegible]	[illegible]
[illegible]	1070	[illegible]	[illegible]	[illegible]
[illegible]	NS	[illegible]	[illegible]	[illegible]
[illegible]				
[illegible]	10[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	991	[illegible]	[illegible]	[illegible]
112	1074	[illegible]	[illegible]	[illegible]
168	1017	[illegible]	[illegible]	[illegible]
224	935	[illegible]	[illegible]	[illegible]
LSD .05	NS	[illegible]	NS	NS
Location 3				
0	646	[illegible]	5	43
56	794	[illegible]	5	38
112	829	[illegible]	5	46
168	720	[illegible]	5	45
224	647	[illegible]	5	47
LSD .05	NS	NS	NS	NS

---

*NS = Not significant at the 0.05 level of probability.

[illegible] influenced [illegible]

[illegible] N Rate	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}	[illegible]			
Location 1				
0	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	[illegible]	[illegible]	[illegible]
168	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	[illegible]	[illegible]	[illegible]	[illegible]
Location 2				
0	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	[illegible]	[illegible]	[illegible]
168	[illegible]	[illegible]	[illegible]	[illegible]
224	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	[illegible]	[illegible]	[illegible]	[illegible]
Location 3				
0	[illegible]	[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	[illegible]	[illegible]	[illegible]
168	[illegible]	[illegible]	[illegible]	[illegible]
224	[illegible]	[illegible]	[illegible]	[illegible]
LSD .05	NS	[illegible]	[illegible]	[illegible]

---

*NS = Not significant at the 0.05 level of probability.

[illegible]

[illegible]	[illegible]	CM	OM	IVOMD
[illegible]	[illegible]	[illegible] kg^{-1}	kg ha^{-1}	[illegible] kg^{-1}
[illegible]				
[illegible]	[illegible]	[illegible]	1,970	[illegible]
[illegible]	[illegible],080	[illegible]	2 490	[illegible]
[illegible]	[illegible],490	[illegible]	2 490	[illegible]
[illegible]	[illegible]600	[illegible]	2 080	[illegible]
[illegible]	[illegible]110	[illegible]	1 870	[illegible]
[illegible]	[illegible]*	[illegible]	NS	[illegible]
[illegible]				
[illegible]	3,850	[illegible]	1 070	[illegible]
[illegible]	3 880	33 5	1,250	31 3
[illegible]	3,630	[illegible]	1,510	[illegible]
[illegible]	[illegible],080	[illegible] 3	1,430	[illegible]
[illegible]	3,600	[illegible]	1,280	36 9
[illegible]	NS	[illegible]	NS	NS
[illegible]				
0	1,050	67 7	7,010	
56	1,440	57 5	8,180	
112	1,860	52 8	9,550	
168	2,000	57 6	11,430	
224	1,700	61 1	10,130	
LSD 05	300	NS	NS	

*NS = Not significant at the 0.05 level of probability.

[illegible]

[illegible]	Forage Yield	[illegible]	[illegible]	Recovery of Applied N
[illegible]		kg ha^{-1}		dag kg^{-1}
[illegible]				
[illegible]	[illegible]	8	[illegible]	
[illegible]	[illegible]	3	[illegible]	91
[illegible]	[illegible]	[illegible]	[illegible]	69
[illegible]	[illegible]	[illegible]	[illegible]	58
[illegible]	[illegible]	3	13	[illegible]
[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	--
[illegible]	[illegible]	[illegible]	--	[illegible]
[illegible]	[illegible]	[illegible]	56	[illegible]
[illegible]	[illegible]	[illegible]	87	32
[illegible]	[illegible]	[illegible]	107	33
Location [illegible]				
0	37	5	35	--
56	50	7	57	39
112	60	8	68	29
168	80	9	89	32
224	100	10	110	33

[illegible] at the [illegible] high apparent [illegible] probably [illegible] of cattle fecal residues absorbed [illegible] as the st[illegible]tes on the site were much greater than at the other locations prior to year of treatment. Larger amounts and distribution of rainfall at location 1 could have attributed to increased recovery of N by developing more massive stoloniferous root systems to capture applied N. The work by Blue (1977) and Beaty et al (1964) showed recoveries ranging from 40-50% for the first 4 years, increases to approximately 70% during the subsequent 6 years (Blue, [illegible]). The increased recovery was attributed to the ultimate development of a massive stolon root system which is capable of absorbing relatively quickly a large amount of N which is stored in the stolons. Beaty et al. (1964) also demonstrated that stolon-root mass of bahiagrass increases with increasing rates of N. Apparently there is a large potential for N to be utilized and immobilized in the development and maintenance of stolon root systems.

Dry matter yield increased to all levels of N when sources of N were averaged over all locations. As reported earlier, source of N had no effect on overall DM yield at any location. The important aspects of forage production for a producer are the amount of forage produced per kg N applied and the cost of producing that forage (Table 4-13).

For the first 56 kg increments of N both anhydrous ammonia and ammonium nitrate cost approximately the same. This is due to the fixed application fee for the anhydrous ammonia. As N rate increases, due to the price difference kg^{-1} of N applied, the anhydrous ammonia becomes less expensive than the ammonium nitrate. Also, the efficiency of

[illegible]

N Rate	[illegible]		Forage DM	[illegible]		[illegible]	[illegible]	[illegible]	
	NH_3	NH_4NO_3		[illegible]	[illegible]			[illegible]	[illegible]
kg ha^{-1}	--- $ ha^{-1} ----		Mg ha^{-1}	[illegible]		[illegible]	[illegible]	[illegible]	
0		---	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56	34.00	35.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	52.00	71.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	70.00	106.[illegible]	[illegible]	[illegible]	[illegible]	16[illegible]	[illegible]	[illegible]	[illegible]
224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	600	16	30.00	59.00

[illegible] ha^{-1} [illegible]

[illegible] ha^{-1} [illegible]

[illegible] ha^{-1} [illegible]

[illegible] with that of other researchers (Beaty, 1964; Blue, 1960, 1970) [illegible] producer should evaluate his own needs for forage production ha^{-1} and [illegible] price costs and benefits when developing a N fertility program The data in Table 4-13 would suggest that a single yearly application of 56 kg N ha^{-1} of either anhydrous ammonia or ammonium nitrate or 112 kg N ha^{-1} of anhydrous ammonia would produce the most economical and [illegible] forage yields of bahiagrass Close grazing or clipping will [illegible] total forage and better utilization and adjusting stock [illegible] maximum utilization would produce forage of higher [illegible] quality Regression equations and correlations for the [illegible] rate on nutrient concentration and content are found in Tables 4-14 and 4-15

Conclusions

The objective of this study was to determine the effect of anhydrous ammonia versus ammonium nitrate as sources of N on the yield and chemical composition of bahiagrass forage

No differences in DM yield were found due to source of N in this study Nitrogen, IVOMD, and P concentrations increased with increased rates of N and were greater when ammonium nitrate was used as the source of N Concentrations of all nutrients increased with increasing rates of N Phosphorus and Cu were found to be deficient in forage at all rates of N for providing NRC requirements for an average milking 450 kg beef cow The ultimate objective of pasture fertilization is to

[illegible]

Dependent Variable	[illegible]		[illegible]	
	Regre[illegible]	[illegible]	[illegible]	[illegible]
dag kg^{-1}				
DM	$Y = 0.53 - 0.000$[illegible]	[illegible]	[illegible]	[illegible]
N	$Y = 1.34 + 0.002X$	[illegible]	[illegible]	[illegible]
P	NS**	—	[illegible]	[illegible]
K	$Y = 0.72 + 0.0011X$	[illegible]	[illegible]	[illegible]
Ca	$Y = 0.49 - 0.00098X +$ [illegible]	[illegible]	NS	[illegible]
Mg	$Y = 0.27 + 0.00023X$	[illegible]	$Y = 0.1$[illegible]	[illegible]
IVOMD	NS	—	$Y = 28.6$ [illegible]	[illegible]
CN	NS	—	NS	—

Table [illegible] Continued

Dependent Variable	Location 3		[illegible]	
	Regression Equation	R	Regression Equation	[illegible]
dag kg^{-1}				
DM	$Y = 0.67 - 0.002X + 5.4E^{-6}X^{2}$	0.38	$Y = 0.62 -$ [illegible] $-$ $2.53E^{-6}$ [illegible]	[illegible]
N	$Y = 1.40 + 0.0021X$	0.36	$Y = 1.79 +$ [illegible]	[illegible]
P	$Y = 0.17 + 0.00012X$	0.14	NS	--
K	NS	--	$Y = 0.65 -$ [illegible]	[illegible]
Ca	NS	--	NS	--
Mg	$Y = 0.21 + 0.00055X + 8.2E^{-6}X^{2}$	0.14	NS	--
IVOMD	NS	--	NS	--
OM	NS	--	NS	--

*X = Coded N rate: X = 0, 56, 112, 168, and 224 kg N ha^{-1}.

**NS = Not significant at the 0.05 level of probability.

[illegible]

Dependent Variable	Location 1		Location 2	
	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				
DM	$Y = 2700 + 53X - $ [illegible]	0.18	$Y = 2915 + 100X - 0.8X^2 + 0.019X^3$	0.26
OM	$Y = 2120 + 40.8X - $ [illegible]	0.1	$Y = 2110 + 89X - 0.7X^2 + 0.0018X^3$	0.23
N	$Y = 34 + 0.85X - 0.00$ [illegible]	0.29	$Y = 31.7 + 1.3X - 0.009X^2 + 2.4E^{-5}X^3$	[illegible]
P	$Y = 4.5 + 0.20X - $ [illegible] $X^2 + 3.86E^{-6}X^3$	0.13	$Y = 3.7 + 0.14X - 0.0009X^2 + 2.4E^{-5}X^3$	[illegible]
K	$Y = 20 + 0.55X - 0.0015X^2$	0.20	$Y = 16.8 + 1.05X - 0.0075X^2 + 1.75E^{-5}X^3$	[illegible]
Ca	$Y = 13 + 0.19X - 0.0005X^2$	[illegible]	$Y = 11.6 + 0.39X - 0.0033X^2 + $ [illegible] X^3	[illegible]
Mg	$Y = 7.5 + 0.16X - 4.18E^{-4}X^2$	[illegible]	[illegible]	[illegible]

[illegible] Continued

Dependent Variable	Regression Equation	R^2	[illegible]	
kg ha^{-1}				
DM	$Y = 2[illegible] + 3[illegible]$	[illegible]32	$Y = 2480 + 64X - 0.48X^2 + 0.0011X^3$	0.18
GM	$Y = 1[illegible] + [illegible]$	0.38	$Y = 1895 + 53.5X - 0.36X^2 + 0.0006X^3$	0.28
N	$Y = 9[illegible] + [illegible]$	0.37	$Y = 30.8 + [illegible]92X - 0.005X^2 - 1.27E^{-5}X^3$	[illegible]
P	$Y = 3.6 + 0.[illegible]$	0.33	NS**	[illegible]
K	$Y = 1[illegible].5 + 0.13[illegible]$	0.[illegible]5	$Y = 13.2 + 0.35X - 0.0009X^2$	[illegible]
Ca	$Y = 7.5 + 0.044[illegible]$	0.26	NS	—
Mg	$Y = 4.2 + 0.0355$	[illegible]3[illegible]	NS	—

*X = Coded N rate, X = 0, 56, 112, 168, and 224 kg N ha^{-1}

**NS = Not significant at the 0.05 level of probability

[illegible]

[illegible] recoveries of N decreased as N rate increased. The [illegible] and efficient forage yields were obtained with one [illegible] application of 56 kg N ha^{-1} of either NH_3 or NH_4NO_3. If additional forage is needed, then a single yearly application of 112 kg N ha^{-1} as NH_3 would be the most economical.

CHAPTER 5

[illegible] DRY MATTER AND [illegible] OF [illegible], [illegible] SORGHUM, [illegible] SORGHUM

Introduction

[illegible] weight is a useful [illegible] growth for [illegible] productivity Knowledge [illegible] matter (DM) production and nutrient uptake and distribution [illegible] to relate to plant growth and development (Jacques et al , 1975) Crop growth is usually more accurately characterized by measurement of dry weight than measurements of fresh weight, which can be strongly influenced by prevailing moisture conditions

Dry weight increase has been described mathematically as a function of physiological, phenological, and environmental factors Increase in dry weight with time is usually characterized by a sigmoidal curve (Leopold and Kriedemann, 1975), in which three primary phases are recognized: expansion, linear, and senescence (Richards, 1969) In the expansion phase, the growth rate (increase in dry weight per unit of time) is initially slow but the rate increases continually as more dry weight is added Accumulation of dry weight is exponential until self-shading or other conditions prevent the increasing leaf area from producing a proportionate increase in the weight of the plant (Watson, 1956, Leopold and Kriedemann, 1975, Duncan et al , 1967) The end of the expansion phase marks the beginning of the linear phase in which the increase in DM continues at a constant rate The final,

[illegible]

The [illegible] ad DM [illegible] in [illegible] maize [illegible] and Colegrove, [illegible]) suggest that the [illegible] of the [illegible] to accommodate assimilat [illegible] their grain [illegible] (1977) pointed out that a potentially [illegible] sink size has been affected by low leaf water potential [illegible] and Allison and Watson (1966) have shown that when grain [illegible], DM that would have been translocated to the grain accumulated in the stem and husk Yamaguchi (1974) stated

> — the [illegible] yield of typical tropical maize is due to short [illegible] duration caused by high temperature, rather than low [illegible] productivity per unit growth duration
>
> — In [illegible] tropical maize, leaves die quickly after silking and the duration from silking to harvest is short, hence the leaf area duration (LAD) is smaller The reason for this characteristic is unknown, but it seems that high temperature is one of the important factors since the senescence of the leaves of tropical maize in highlands and in lowlands in winter is slow where temperatures are low
>
> The grain production per unit of LAD (G/LAD) of tropical maize is large In other words, the efficiency of green leaves for producing grain is not at all low. Therefore, the small LAD may perhaps be one of the yield limiting factors of typical tropical maize
>
> — in tropical maize there is a loss of total dry weight (TDW) with approaching maturity There is usually no such loss in temperate maize Significant loss of stem weight is only reported from the temperate area by defoliation at silking
>
> As this loss was also observed in tropical highland maize this characteristic may be genetic The probable explanations for this TDW decrease are (i) respiratory loss from the stem and husk, which can not be replaced by the current assimilates or (ii) more probably, translocation to the ear of materials previously held in the stem; this process is accompanied by a rapid respiratory loss in the stem

> [illegible] of [illegible] highland [illegible] is also [illegible]
>
> The longer [illegible] of the culm of tropical [illegible] continued [illegible] silking. This growth [illegible] culm after [illegible] with the growth of [illegible] and result in a [illegible] index.
>
> The [illegible] of tropical varieties [illegible] about 2,000 [illegible] the climatic conditions [illegible] limits of [illegible]. This number is much smaller [illegible] 800 kernels [illegible] more reported as high yielding temperate varieties. This difference is mainly due to [illegible] difference in number of kernels per ear. In tropical [illegible] maize, this small number was compensated for by [illegible] kernel size and produced a high grain yield. Nevertheless, [illegible] evidence reveals that the grain yield of tropical maize [illegible] frequently limited by the sink size (kernel number per ear) than on the source of photosynthates.
>
> It should be mentioned here that the various characteristics of tropical maize described above may be interrelated, for example, LAD and the number of kernels. Thus, it is difficult to state which is caused environmentally or genetically. However, at least some of them are under genetic control. In other cereals, for example, in rice, improvements of plant traits have succeeded in increasing the yield ability of tropical varieties. These facts suggest that varietal improvement is definitely one of the important approaches for obtaining high yields of tropical maize (p. 77)

Some investigations have measured the inorganic nutrient uptake by corn and sorghums (Sorghum bicolor L. Moench). It has been recognized that amounts of most nutrients removed by a crop harvested for silage may be much more than when the same crop is harvested for grain (Hanway, 1966). A considerable range in values can be expected for each element, since soil drainage and fertility, climatic conditions, plant population, crop species and genotype, and fertilizer practice can influence crop content of each element (Fribourg, 1974). Work by Benoit et al (1965) and Owen and Furr (1967) showed little difference in the

[illegible]

[illegible]

uptake by [illegible] sorghums. The amount [illegible] plant parts [illegible] considerable range: [illegible] to 220 kg [illegible] to 34 kg P ha^{-1}, [illegible] to 71 kg K ha^{-1}, 8 to 55 kg Ca ha^{-1}, and [illegible] kg Mg ha^{-1}. Since the quantities removed are the products of harvested plant wet weights and percent composition, they are influenced not only by the climatic, edaphic, genotypic, and management considerations, but also by soil nutrient availability. Growth and DM production in grain sorghum have been reported by several workers. Vanderlip and Reeves (1972), who defined 10 growth stages of grain sorghum from emergence to physiological maturity, suggested that by using these stages as standards the timing of sampling or treating sorghum could be described accurately in relation to the morphological or physiological age or status of the plant. They reported that the general pattern of DM accumulation was the same for different grain sorghum hybrids and that late maturing hybrids tended to be heavier at each stage of development than did earlier maturing hybrids.

Jacques et al. (1975), in studies of grain sorghum hybrids, found that Ca and Mg uptake preceded DM production, and Ca was generally taken up more rapidly than Mg during vegetative growth. When vegetative growth had been completed, more than half of the plant's total Ca and Mg uptake had occurred. Whole plant nutrient concentrations decreased through most of plant growth. Zinc and Ca concentrations did not decrease as much during grain development as during vegetative growth. Lockman (1972a, b) reported that soil acidity, soil fertility, [illegible] s affect [illegible] (1975) [illegible] r emergence [illegible] [illegible] ised faster th [illegible] and [illegible] Hanway ([illegible]) [illegible] influenced the [illegible] markedly change th [illegible] elements in the pl [illegible] grain sorghums was lim [illegible] 1976, Hanway, 19 [illegible]

[illegible] tive of this study [illegible] tration and nutrie [illegible] grain sorghum, and [illegible]

Materials [illegible]

[illegible] study was conducted during [illegible] at one location [illegible] r Brand 'YOMO6' tropical corn, DeKalb 'EXA 816' [illegible] Pioneer Brand '923' forage sorghum, and Pioneer Brand '822' [illegible] sorghum planted into 15-year-old bahiagrass (Paspalum notatum L. Flugge) (c v 'Pensacola') and The genotypes were planted on May [illegible], 1984, on an Arredondo fine sand (loamy, siliceous hyperthermic Grossarenic Paleudult) Other methods and materials for this study were identical to those cited in Chapter 2 with the following exceptions

Corn was planted at 45,000 plants ha^{-1}, and the forage sorghum at 130,000 plants ha^{-1}, and the grain sorghum at 75,000 plants ha^{-1}.

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] during [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] July [illegible] and September [illegible] [illegible] were sampled [illegible] for the first two harvests and [illegible] thereafter. [illegible] [illegible] row were sampled for the first two harvests for [illegible] [illegible] with seven plants sampled thereafter. All [illegible] [illegible] weighed for fresh weight and moisture determination [illegible] [illegible] dried at 60-70 C in forced air oven. All [illegible] [illegible] ground in a Wiley mill to pass a 1 mm stainless steel [illegible] [illegible] airtight plastic bags until further analysis.

[illegible]

Dry matter accumulation [illegible] during initial growth, then from approximately 60 days after [illegible] when the plants were in bloom, growth began a linear phase [illegible] 5-1) as described by Richards (1969). The two tropical corn hybrids ('Pioneer YOMO6' and 'DeKalb EXA 816') reached physiological maturity at 85 days, at which time DM accumulation started to decline. Moisture did not appear to be limiting until near physiological maturity (Table 5-1). The 'Pioneer 923' forage sorghum and the 'Pioneer 8222 grain sorghum continued to accumulate DM through the final harvest at 105 days after planting. At bloom, approximately 20 percent of the total DM had accumulated approximately 58, 30, and 45% of their DM, respectively. Dry matter accumulation appeared to be nearly linear following bloom of each genotype. At physiological maturity, the corn hybrids lost DM rapidly as the plants started senescing. This accumulation followed

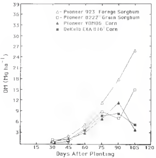


Figure 5-1. Effect of days after planting on the DM accumulation of four cultivars of tropical corn and sorghum.

Table [illegible] [illegible], 1983-84 at [illegible] [illegible], grain sorgh[illegible] [illegible] [illegible] [illegible]ed ante bablepr[illegible]

[illegible]	Loc[illegible]
	— mm —
[illegible]	
[illegible]	
[illegible]	30
[illegible]	76
[illegible]	
[illegible]	8
[illegible]	41
[illegible]	8
[illegible]	7
[illegible]	
[illegible]	
[illegible]	89
[illegible]	
[illegible]	
7/25	76
7/30	18
8/5	38
8/10	
8/15	18
8/20	51
8/25	
8/30	
9/5	10
9/10	

[illegible] [illegible] rghum [illegible] quce [illegible] preceded DM production. Serious [illegible] and DM accumulation. More than half [illegible] nutrient uptake occurred before maximum vegetative DM was [illegible]ed in grain sorghum. Vanderlip and Reeves (1972) reported that the general pattern of [illegible] accumulation was the same for different [illegible] hybrids and that late maturing hybrids tended to be heavier at each stage of development than did earlier maturing hybrids. Shipley et al. (1971) reported that in irrigated grain sorghum DM production was slowest from emergence to the six to eight leaf stage and from bloom to milk and was most rapid during the early- to late-boot stage. Lane and Walker (1961) reported that applying N and P resulted in a faster growth rate and plants of larger size and dry weight.

Organic matter concentrations for all cultivars tended to follow similar trends in that there was a rapid increase in OM concentration in the early vegetative stages and then the concentration stabilized near bloom for all cultivars (Figure 5-2). Organic matter accumulation followed DM accumulation for each genotype.

Nitrogen and K concentrations increased rapidly during the first 30 days after planting and decreased thereafter (Figures 5-3 and 5-4). Since total DM varied with each genotype, total N uptake also varied. The forage sorghum accumulated 265 kg N ha^{-1} which was approximately 60% more uptake than was applied. The variety 8222 grain sorghum, YOMOb corn, and EXA 816 corn accumulated 160, 140, and 90 kg N ha^{-1}, respectively (Figure 5-3). Potassium uptake was fairly constant after bloom for 'EXA 816', however, K accumulated almost linearly in the

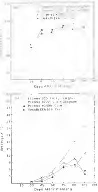


Figure 5-2. Effect of days after planting on the DM concentration (a) and content (b) of four cultivars of tropical corn and sorghum.

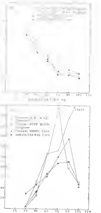
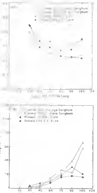


Figure [illegible]-3 Effect of days after planting on the N concentration (a) and content (b) of four cultivars of tropical corn and sorghum



[illegible] – Effect of days after planting on the P concentration (a) and content (b) of four cultivars of tropical corn and sorghum other [illegible] d that to[illegible] in N a[illegible] production In their experiment N continued [illegible] in the grain as in[illegible] the plants were sampled This indicates that N moved from the other tissues of the plant Lockman (1[illegible]) [illegible] that K levels in [illegible] sorghum plant samples decreased [illegible] linearly with age Dry weather appreciably decreased relative K levels in seedling samples in one [illegible] of his study Anderson et al (1985) stated that the response of [illegible] to increase N fertility differs considerably Some experimental hybrids show increases in protein content and/or grain yield as N rate increase (Ramprath et al , 1973; Warren et al , 1980; Nelson, 1984) Several reports indicate that source-sink relationships are important in the accumulation and distribution of N and DM Ramerath et al (1982) found that low N uptake in corn before silking was associated with a low harvest index Hanway (1962b) stated that the pattern of N accumulation by plants is influenced by the seasonal pattern of N availability in the soil Seasonal pattern will vary with different times and methods of application of N fertilizer and the rate of mineralization of N from the soil organic matter will vary among different soils and different seasons Potassium accumulation in Hanway's (1962c) study continued until a later stage of maturity and there was no loss of K from the plants during the latter part of the season Similar results occurred in the sorghum cultivars in the present study, but the corn hybrids did lose K after physiological maturity which is in agreement with Sayre's (1948) data

Phosphorus ranged from 0.35 to 0.45 dag kg $^{-1}$ at the first harvest among the cultivars The concentration of P declined rapidly due to a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], our decreas[illegible] [illegible] [illegible] hybrids after [illegible] [illegible]. Bates (1971) observed that the pattern of nutrient content with age varies with the species and with the nutrient. Phosphorus concentration with age is probably due to the changing nutrient content of a given tissue with age, such as the increasing proportion of ears and a decreasing proportion of leaf tissue. Hanway (1962c) found that the P accumulation pattern was similar to the DM accumulation pattern except more rapid early in the season.

Calcium and Mg concentrations reacted similarly for corn and sorghum. However, concentrations were higher for the two sorghums than for the tropical corn hybrids (Figures 5-6 and 5-7). Calcium was absorbed more rapidly than Mg and accumulated to a greater level in the sorghums than the corn hybrids. Also, more Ca than Mg was accumulated by all the cultivars. Jacques et al. (1975) found in sorghums that Ca and Mg uptake preceded DM production, and Ca was generally taken up more rapidly than Mg during vegetative growth. When vegetative growth had been completed, more than half of the plant's total Ca and Mg uptake had occurred. In one study, Lockman (1972a) reported that seasons affected nutrient levels in grain sorghum and that dry years caused high Ca and Mg, as well as other nutrients, in sorghum leaves, probably because K would be less mobile in the soil. Fribourg et al. (1976) stated that, in general, nutrient uptake of N, P, K, Ca, and Mg increased linearly with increasing yield of either crop genotype used. However, grain sorghum above-ground plant parts tended to contain

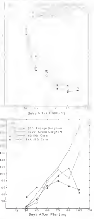


Figure 5.5 Effect of days after planting on the K concentration (a) and content (b) of four cultivars of tropical corn and sorghum

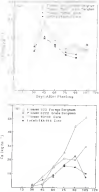


Figure 5-6 Effect of days after planting on the Ca concentration (a) and content (b) of four cultivars of tropical corn and sorghum

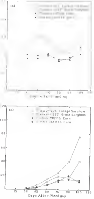


Figure 5.7 Effect of days after planting on the Mg concentration (a) and content (b) of four cultivars of tropical corn and sorghum

[illegible]

[illegible] other [illegible] studied. [illegible] concentrations were highest during [illegible] early vegetative stages then reduced due to a dilution effect [illegible] [illegible] accumulation between 30 and 45 days after planting [illegible] [illegible] of Fe to did to increase in the two cor[illegible] [illegible] flower formation in [illegible]. The Fe continued to [illegible] [illegible] the final harvest at 105 days after planting [illegible] [illegible] of plant samples could explain the erratic [illegible] [illegible] in the various genotypes. Jacques et al. [illegible] with non-washed samples, showed that no vali[illegible] [illegible] in blade and sheath tissue, and possibly head [illegible] [illegible] if samples were not washed thoroughly. However, [illegible] differences between washed and non-washed samples were found [illegible] [illegible] Cu or Mn content in any plant part.

[illegible], Cu, and Zn followed similar trends in concentration content (Figures 5-9, 5-10, and 5-11). Manganese concentrations ranged from the first to final harvest from 87-34, 83-47, 72-37, and 46-40 mg kg^{-1} for '923', 'R222', 'YOMO6', and 'EXA 816', respectively. Jacques et al. (1975) found whole plant nutrient concentrations decreased through most plant growth. Zinc and Cu concentrations did not decrease as much during grain development as during vegetative growth. Nutrient uptake generally had reached 50% or more of total uptake in the plants when they completed vegetative growth. Nutrient uptake preceded DM accumulation. These same trends were true in the current study for Mn, Cu, and Zn.

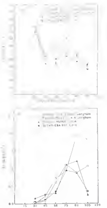


Figure [illegible] Effect of days after planting on the Fe concentration (a) and content (b) of four cultivars of tropical corn and sorghum

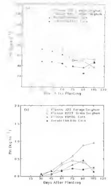
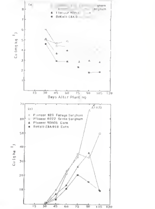


Figure 5-9 Effect of days after planting on the Mn concentration (a) and content (b) of four cultivars of tropical corn and sorghum



[illegible]-10 Effect of days after planting on the Cu concentration (a) and content (b) of four cultivars of tropical corn and sorghum

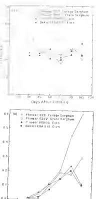


Figure 3 11. Effect of days after planting on the Zn concentration (a) and content (b) of four cultivars of tropical corn and sorghum [illegible] by the final harvest the sorghums removed [illegible] (Table 5-4) Fribourg et al (1976) found [illegible] and sorghums where both crops [illegible] had been applied as fertilizer, ind[illegible] available K and N were utilized by the [illegible] Fribourg et al (1976) study was [illegible] N was applied at 135 to 170 $kg\ ha^{-1}$

Conclusions

[illegible]ry matter accumulation and DM concentration [illegible] rapidly after 30 days post planting Nitrogen, P, K, Ca, [illegible] and Zn concentrations increased rapidly during early vegetative growth and decreased rapidly thereafter Iron concentration tended to be erratic throughout all harvest dates The concentrations of N, Ca, Mg, Mn, Cu, and Zn were higher in the sorghum than in the corn hybrids The other elements studied tended to be higher in corn hybrids The nutrient uptake tended to follow DM accumulation particularly after the early vegetative stages of growth Because environmental conditions do vary over short periods of time they will affect the validity of plant analysis if they alter the nutrient concentration at sampling, whether or not they alter any critical concentration A number of authors reporting year-to-year variation in nutrient content have considered weather as a major cause (Bates, 1971) As noted, Fribourg et al (1976) stated that since quantities removed are the products of

Table 5-2 Dry matter accumulation and agronomic [illegible] sorghum, and forage sorghum planted in [illegible]

Hybrid	Grain yield	Forage yield	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	——— kg ha^{-1} ———			[illegible]		[illegible]	[illegible]
Pioneer Brand 923[illegible] forage sorghum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
'Pioneer Brand 82[illegible] grain sorghum	[illegible]	[illegible]	[illegible]	–	[illegible]	[illegible]	[illegible]
'Pioneer Brand [illegible] tropical corn	2,010	1,740	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
'DeKalb XL 816' tropical corn	2 110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]. [illegible] [illegible] planted into bahiagrass [illegible]

Hybrid	N	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	dag kg^{-1}					[illegible]				[illegible]
'Pioneer Brand 923' forage sorghum	1.02	0.33	0.88	0.20	0.29	70	[illegible]	[illegible]	5	95.8
'Pioneer Brand 8222' grain sorghum	1.12	0.42	1.0[illegible]	0.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
'Pioneer Brand [illegible]' tropical corn	1.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] tropical corn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Hybrid	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	kg ha^{-1}									[illegible] ha^{-1}
'Pioneer Brand 9[illegible]' forage sorghum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
'Pioneer Brand 8222' grain sorghum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
'Pioneer Brand YCM06' tropical corn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
'DeKalb EXA 816' tropical corn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

considerations [illegible]

CHAPTER 6
SUMMARY AND CONCLUSI[illegible]

[illegible] deficient state with many thousands of [illegible] each year for stocking or finishing [illegible] Florida currently ranks 9th in the natio[illegible] There are also some 3 million acres of [illegible] and which might be more fully utilized [illegible] forage production.

Several feedlots in the state are in need of good quality [illegible] profitable beef production. At the current time there [illegible] freight costs incurred for shipping grain from the midwestern [illegible] States to utilize in cattle and poultry rations in the State [illegible]

Tropical corn or grain sorghum planted in the summer in multicropping systems could take us a long way toward meeting the demand for high energy feed grains by feedlot operators. This multicropping or intensification of land and resources is needed for Florida farmers to adequately compete and stay in business. The adage is no longer, "How much can I produce?" but "How much can I produce profitably?"

If summer planting of corn or grain sorghum were feasible, this could add to our economic base and maximize use of our farm resources and management. Also, a bahiagrass sod, under two tillage systems, has served as the soil conservation component during the late fall and winter months, while in late summer it seems to serve as a trap crop

[illegible]

major [illegible] reduced [illegible] irrigation [illegible] management [illegible] irrigation is expensive with [illegible] of approximately [illegible][1] The Florida Crop Reporting Service reported the [illegible] the 1983-84 growing seasons; the area planted [illegible] 1984 totaled 101 250 ha, 49 more than 1983 when many growers participated in acreage reduction programs. Of the total ha planted, 85 050 were harvested for grain, 72% more than the year before. The average yield was 3450 kg ha^{-1}, which included irrigated as well as non-irrigated land. Drought damage to late corn that was not irrigated was the primary cause of the yield reduction as most of the early crop and irrigated corn produced good to excellent yields. The value of the corn produced for grain was placed at $41,633,000, up 34% from the year before.

One objective of this study was to determine the effect of anhydrous ammonia (NH_3) as the sole source of N when tropical corn (*Zea mays* L.) was no-tillage planted into bahiagrass sod. Nitrogen is the largest and probably the most expensive fertilizer component used in producing corn, grain sorghum (*Sorghum bicolor* L. Moench), and bahiagrass forage with NH_3 being one of the least expensive sources of N available.

The tropical corn showed a response to the 56 kg N ha^{-1} rate for grain, residue, and whole plant dry matter (DM) yields at two locations. The third location showed a significant increase for the yield

---

parameters [illegible] [illegible] [illegible] [illegible]

increase [illegible] [illegible] [illegible] [illegible]

insufficient [illegible] during the [illegible] [illegible]

decreased grain [illegible] more than [illegible] [illegible] As

were more [illegible] the highest [illegible] was

applied [illegible] to the physiological [illegible] and the

plants respond [illegible] levels of fertility [illegible] stress

Grain, stalk [illegible] plant DM yields [illegible] in response

to increased [illegible] fertility at locations [illegible], but were

quadratic at [illegible] for grain and whole plant DM yield probably as

a result to moisture stress The concentration of nutrients in grain

varied with location and N fertility did not affect Ca, Mg, Fe, Mn, Cu

or Zn at locations 1 or 3 Nitrogen content of grain and stalks

increased linearly in all locations Grain yield kg N in the aerial

portion of the plant ranged from 25 to 44 kg ha $^{-1}$ The N content of

stalks responded the same as grain The concentration and content of

most other nutrients did not respond to N rate at any location or only

responded to the 56 kg N ha $^{-1}$ rate and did not increase above that rate

The analysis of diagnostic samples indicated that N and Fe were

the only elements increased by N rate when youngest mature leaves were

sampled at 40 days post emergence Whole plant samples harvested at 40

days exhibited a change in nutrient concentration for N, Ca, Mg, Fe, Mn,

and Cu to increasing rates of N Ear leaf sampled at mid-silk showed

an increase to N rate for OM and IVOMD The concentration of N and P

were lower than the CNL values recommended by Tyner (1946) for suffi-

ciency levels in corn ear leaves Only K met the CNL values recom-

mended by various researchers (Anderson et al., 1985) Climatic

[illegible]

[illegible] sampling methods [illegible] indicate that N, Ca, and Zn were all [illegible] and whole plant DM yield when the [illegible] sampled. When the whole [illegible] and Ca were positively correlated with final yields [illegible]ively correlated. [illegible] and Mg were also positive[illegible] with final DM yield when this method was utilized. When the [illegible] at silking was sampled, N and Ca were positively correlated and [illegible]tively correlated with grain yield. Nitrogen, Ca, and IVOMD were [illegible]tively correlated to stalk and whole plant DM yields.

A second objective of this study was to determine the effect of NH_3 as the sole source of N for grain sorghum no tillage planted into bahiagrass sod. Grain sorghum DM yield for grain and whole plant increased at the 56 kg N ha^{-1} rate at two locations and to the 112 kg N ha^{-1} rate for the third location. All three locations increased in residue DM yield up to the 112 kg N ha^{-1} rate. Sorghum webworm at location 2 and moisture deficits at location 1 had a greater effect on grain yields than on residue yields. As with corn, it was found that 224 kg N ha^{-1} reduced yields where moisture was deficient. Grain yield and whole plant yield averaged over the three locations were 560 and 342 dag kg^{-1} more than the control when 168 kg N ha^{-1} was applied.

Grain N concentration increased to the 112 kg N ha^{-1} rate at location 1 and to 224 kg N ha^{-1} rate at locations 2 and 3. The grain concentration of P, K, Ca, Mg, Fe, Mn, Cu, and Zn was not affected by

[illegible]

orghum [illegible] three loc[illegible] 39, 5[illegible] from appli[illegible] kg N ha^{-1}, [illegible] and 32 dag kg^{-1} [illegible] 16% [illegible]

In [illegible] experiments, concentration [illegible] youngest mature leaf at [illegible] and third leaf below the [illegible] of grain yield [illegible] DM. Whole [illegible] correlations for N [illegible] the leaf [illegible] yield of grain, residue, and whole plant DM [illegible] could also be invaluable to help in determining [illegible] early in the growing season so that additional fertili[illegible] management methods could be applied so that fertili[illegible] would not be limiting to yields.

The third objective of this study was to determine the effect of NH_3 versus ammonium nitrate (NH_4NO_3) as sources of N on the yield and chemical composition of bahiagrass forage. No differences in DM yield were found due to source of N in this study. Nitrogen, IVOMD, and P concentrations increased with increased rates of N and were greater when NH_4NO_3 was used as the source of N. However, these differences were small although significant.

Concentration of all nutrients increased with increasing rates of N. Phosphorus and Cu were found to be deficient in forage at all rates of N for providing National Research Council (NRC) requirements for an average milking 450 kg beef cow. The ultimate objective of pasture [illegible] system [illegible] decreased [illegible] that up to [illegible] significant yield in [illegible] most forage product [illegible] ent of trucking [illegible] problem. The cost of either NH_3 [illegible] However, if additional [illegible] ntage by using NH_3 at 168 kg [illegible] ha^{-1} [illegible]

[illegible] tive of this study was to measure the DM accumulation, nutrient concentration, and nutrient content of three genotypes: tropical corn, grain sorghum, and forage sorghum. Dry matter and DM concentration and content increased rapidly after 30 days post planting. Nitrogen, P, K, Ca, Mg, Fe, Mn, Cu, and Zn concentrations increased rapidly during early vegetative growth and decreased rapidly thereafter. Iron concentration tended to be erratic throughout all harvest dates. This could be due to contamination of plant samples with soil. The concentration of N, Ca, Mg, Mn, Cu, and Zn were higher in the sorghum than in the corn hybrids. The other elements studied tended to be higher in the corn hybrids. The nutrient uptake tended to follow DM accumulation, particularly after the early vegetative stages of growth.

A number of authors reporting year to-year variation in nutrient content have considered weather as a major cause (Estes, 1971) [illegible] edaphic, gene[illegible] nutrient avail[illegible] irrigation as [illegible] come [illegible] founding [illegible] distribution [illegible] moisture and quality [illegible] for grai[illegible] production [illegible] The [illegible] were not [illegible] summer rainfall [illegible] back [illegible] in the months of August [illegible] Research needs [illegible] look for drought resist[illegible], and high quality [illegible] and grain sorghums which might fit into this management [illegible]

Also, the regrowth of sorghums and the residue of sorghums and tropical corn along with regrowth of kohlagrass from these multicropping systems would be desirable for the fall feeding of the beef herd. Nitrogen concentration of grain sorghum residues were consistently higher than that of corn while IVOMD values were lower in grain sorghum. Crop residues of grain sorghum and corn have attracted attention as an alternate economical forage resource for livestock utilization. There are few data available on agronomic production factors affecting yield and quality of crop residues (Perry and Olson, 1975).

The time is here for economic evaluations of the most profitable multiple cropping systems. More research is needed to evaluate and [illegible] nutrition and crop [illegible] cropping and/or till[illegible] practical on-farm use. Florida's [illegible] among the [illegible] the United States and the development [illegible] year-round for[illegible] systems will require exact knowledge of element removals [illegible] fertility will not become a limiting factor in crop pro[illegible]

[illegible]

ANHYDROUS AMMONIA AS A SOURCE OF NITROGEN FOR TROPICAL CORN PLANTED INTO BAHIAGRASS SOD BY MINIMUM TILLAGE METHODS

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				Location I						
0	0-20	35	34	283	[illegible]	13	5	06	[illegible]	[illegible]
56		47	46	374	[illegible]	[illegible]	7	07	[illegible]	[illegible]
112		49	[illegible]	[illegible]	[illegible]	[illegible]	6	08	[illegible]	[illegible]
[illegible]		37	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	20-40	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table A-1. Continued

N Rate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]									
		[illegible]									
0	[illegible]	[illegible]	18	29	281	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		[illegible]	2	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible] continued

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.08	[illegible]	[illegible]
112		[illegible]	[illegible]	[illegible]	[illegible]	15	5	.11	[illegible]	[illegible]
168		[illegible]	[illegible]	[illegible]	9	14	4	.09	[illegible]	[illegible]
224		[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	1	[illegible]	[illegible]
0	[illegible]	61	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		51	28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		34	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					
[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]
Grain		1.00	[illegible]	[illegible]	0.88
Stalk			[illegible]	[illegible]	[illegible]
[illegible] plant				[illegible]	[illegible]
[illegible]					[illegible]

[illegible]

Table A-3 Correlation coefficients for dry [illegible] subsoil planted into bahiagrass [illegible]

	N Treatment	Grain	[illegible]	[illegible]	[illegible]
kg ha^{-1}					
N Treatment	1.00	[illegible]	[illegible]	[illegible]	[illegible]
Grain		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	[illegible]
[illegible]					1.00

Table A 4 Correlation coefficient for dry [illegible] subsoil planted into bahiagrass [illegible]

	N Treatment	Grain	[illegible]	[illegible]	[illegible]
kg ha^{-1}					
N Treatment	1.00	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		1.00	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	[illegible]
[illegible]					[illegible]

Table A-5 Correlation equations for agron[illegible] into bahiagrass sod at locati[illegible]

	DM grain	Grain yield	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DM grain	1.00	NS*	0.53	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grain yield		1.00	0.42	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shelling %			1.00	[illegible]	[illegible]	NS	NS	NS	-0.31
# of plants				1.00	[illegible]	NS	NS	NS	NS
# of ears					[illegible]	0.91	NS	0.54	NS
[illegible]						1.00	NS	0.56	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]
[illegible]								[illegible]	[illegible]
[illegible]									[illegible]

*[illegible]

Table [illegible]. Correlation coefficients for agronomic variables of corn no-tillage in-row subsoil planted into bahiagrass sod at location 2

	DM grain	Grain yield	Shelling %	# of plants	# of ears	Ear/plant	[illegible]	Stalk yield	[illegible]
DM grain	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grain yield		1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shelling			1.00	[illegible]	[illegible]	[illegible]	[illegible]	0.86	[illegible]
# of plants				1.00	[illegible]	[illegible]	NS	[illegible]	[illegible]
# of ears					1.00	0.86	NS	[illegible]	[illegible]
Ear/plant						1.00	NS	[illegible]	[illegible]
DM stalk							1.00	[illegible]	[illegible]
Stalk yield								1.00	[illegible]
% Treatment									[illegible]

[a] NS = Not significant at the 0.05 level of probability.

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grain yield	[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shelling %			1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
# of plants				1.00	[illegible]	NS	[illegible]	[illegible]	[illegible]	[illegible]
# of ears					1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]
DM stalk						1.00	NS	NS	[illegible]	[illegible]
Stalk yield							1.00	0.78	0.79	[illegible]
Plant height								1.00	0.70	[illegible]
Ear/plant									1.00	[illegible]
N Treatment										[illegible]

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[*] NS = Not significant at the [illegible]

Table [illegible].6 Correlation coefficients for corn grain mineral [illegible]

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	OM	IVOMD	[illegible]
N	1.00	NS[a]	NS	NS	NS	NS	0.38	NS	NS	-0.57	NS	[illegible]
P		1.00	0.77	NS	0.65	NS	0.79	NS	NS	NS	NS	[illegible]
K			1.00	NS	0.86	NS	0.74	0.39	NS	0.53	NS	NS
Ca				1.00	NS	NS	NS	NS	NS	NS	NS	[illegible]
Mg					1.00	NS	0.63	NS	NS	[illegible]	[illegible]	[illegible]
Fe						1.00	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	0.41	NS	[illegible]	[illegible]	[illegible]
Cu								1.00	0.56	0.36	NS	[illegible]
Zn									1.00	NS	NS	[illegible]
OM										1.00	-0.3[illegible]	[illegible]
IVOMD											1.00	[illegible]
TRT												1.00

[a] NS = [illegible] at the 0.05 level of [illegible]

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.37	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	NS	[illegible]
Mn							1.00	[illegible]	[illegible]	0.46	[illegible]	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]	[illegible]
Zn									1.00	[illegible]	[illegible]	[illegible]
OM										1.00	NS	NS
IWGHD											1.00	NS
TBT												[illegible]

[illegible]

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		1.00	0.92	0.20	0.93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			1.00	0.50	0.83	NS	[illegible]	NS	[illegible]	[illegible]	[illegible]
Ca				1.00	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]								[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									[illegible]	[illegible]	[illegible]
OM										[illegible]	[illegible]
TRI											[illegible]

[illegible]

Table [illegible] Correlation coefficients [illegible] corn stalk [illegible]

	[illegible]	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	NS*	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	NS	NS	NS	NS	NS	NS	NS	NS	[illegible]	[illegible]
K			1.00	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ca				1.00	0.49	NS	NS	NS	-0.58	NS	NS	[illegible]
Mg					1.00	NS	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]	[illegible]
OM										[illegible]	[illegible]	0.83
IVOMD											1.00	[illegible]
TRT												[illegible]

*NS = Not significant at the 0.05 level of probability.

Table A-[illegible]. [illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		1.00	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NS
Cu								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]	[illegible]
OM										1.00	[illegible]	[illegible]
IV(PU)											[illegible]	[illegible]
TRT												1.00

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*NS = Not [illegible]

Table A-13 Correlation coefficients for corn stalk mineral concentration at location 3

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	OM	TRT
N	1.00	NS*	NS	0.44	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	NS	-0.44	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	NS	NS	NS	0.61	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	0.52	NS	0.48	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	NS	NS	0.50	NS	[illegible]	[illegible]
Fe						1.00	NS	NS	NS	NS	[illegible]
Mn							1.00	0.40	NS	-0.49	[illegible]
Cu								1.00	NS	NS	0.60
Zn									1.00	NS	-0.51
OM										1.00	[illegible]
TRT											1.00

*NS = Not significant at the 0.05 level of probability.

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	IVOMD	[illegible]
[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.90	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]	[illegible]
Zn									1.00	[illegible]	[illegible]	[illegible]
OM										1.00	[illegible]	[illegible]
IVOMD											1.00	[illegible]
[illegible]												[illegible]

[illegible]

Table A-15. Correlation coefficients for [illegible]

	N	P	K	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	0.91	0.98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]								1.00	[illegible]	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]	[illegible]
OM										[illegible]	[illegible]	[illegible]
IVOMD											[illegible]	[illegible]
TNT												[illegible]

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	0.91	0.90	[illegible]	0.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	1.00	0.72	0.99	0.79	0.98	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	0.69	0.98	0.78	0.98	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									[illegible]	[illegible]	[illegible]
[illegible]										[illegible]	[illegible]
[illegible]											1.00

[illegible]

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	OM	IVOMD	TRT
N	1.00	0.78	0.81	0.69	0.74	0.77	0.86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.67	0.71	0.70	0.65	0.74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	0.78	0.84	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	0.89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	[illegible]	[illegible]	0.84	[illegible]	[illegible]
Cu								1.00	0.40	0.86	0.86	[illegible]
Zn									1.00	0.47	0.40	[illegible]
OM										1.00	[illegible]	[illegible]
IVOMD											1.00	[illegible]
TRT												1.00

[a] [illegible]

[illegible]

	N	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	0.86	0.[illegible]6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	0.8[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										[illegible]	[illegible]	[illegible]
IVDMD											[illegible]	[illegible]
TRY												[illegible]

[illegible]

[illegible]

	[illegible]	[illegible]	K	Ca	Mg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	0.81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	0.91	[illegible]	[illegible]	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]
[illegible]										1.00	[illegible]
TRT											[illegible]

*NS = Not signi[illegible]

APPENDIX B

ANHYDROUS AMMONIA AS A SOURCE OF NITROGEN FOR GRAIN SORGHUM PLANTED INTO BAHIAGRASS SOD BY MINIMUM TILLAGE METHODS

Table [illegible] Soil test results following grain sorghum no tillage in-row subsoil planted [illegible] bahiagrass sod as influenced by rates of anhydrous ammonia at three locations

N Rate	Depth	P	K	Ca	Mg	Fe	[illegible]	[illegible]	[illegible]	[illegible]
kg ha $^{-1}$	cm	[illegible]								
		[illegible]								
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	20-40	22	26	155	34	14	5	.08	[illegible]	[illegible]
56		26	20	126	34	15	4	.07	[illegible]	[illegible]
112		24	22	126	33	15	4	.07	18	[illegible]
168		23	18	92	[illegible]	15	[illegible]	0	15	[illegible]
224		20	[illegible]	115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible] (continued)

Rate	Depth	N	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
$\mathrm{kg\ ha^{-1}}$	cm										
			[illegible]								
0	0–20	.04	8	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		.04	30	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		.04	21	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		.04	21	44	369	[illegible]	[illegible]	[illegible]	15	88	[illegible]
224		.04	23	56	409	[illegible]	[illegible]	[illegible]	13	85	[illegible]
0	20–40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]

[illegible] [illegible]

N Rate	Depth	[illegible]	[illegible]	[illegible]	Mg	Fe	Mn	Cu	Zn	[illegible]
kg ha^{-1}	cm			mg kg^{-1}						
				Location						
0	0-20	43	46	146	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		50	40	154	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		41	45	166	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		41	46	130	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224		46	43	159	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	20-40	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56		49	32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112		48	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168		47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224		59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	N Treatment	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		1.00	[illegible]	[illegible]	[illegible]
Stalk			1.00	[illegible]	0.46
Whole plant				1.00	[illegible]
Grain/stalk					[illegible]

Table 8-3 Correlation [illegible]
location 2

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}					
N Treatment	1.00	[illegible]	[illegible]	[illegible]	[illegible]
Grain		1.00	[illegible]	[illegible]	[illegible]
Stalk			1.00	[illegible]	[illegible]
Whole plant				1.00	[illegible]
[illegible]					1.00

[illegible]

	N Treatment	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}					
N Treatment	1.00	[illegible]	[illegible]	[illegible]	[illegible]
Grain		1.00	0.88	[illegible]	[illegible]
Stalk			1.00	[illegible]	NS
Whole plant				[illegible]	[illegible]
Grain/stalk					[illegible]

[illegible]

Table [illegible] Correlation [illegible] and dry matter accumulation of grain sorghum at [illegible]

	Whole plant accumulation	[illegible]	[illegible]	[illegible]
Whole plant accumulation	1.00	[illegible]	[illegible]	0.86
[illegible]		[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]
N Treatment				[illegible]

[a]NS = Not significant at the [illegible]

Table [illegible]. Correlation coefficients for agronomic variables and dry [illegible] accumulation of grain sorghum at location 2

	Whole plant accumulation	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percent [illegible]		[illegible]	[illegible]	0.5
# of plants			[illegible]	[illegible]
N Treatment				[illegible]

*NS = Not significant at the [illegible]

[illegible]

	Whole plant accumulation	[illegible]	[illegible]	[illegible]
Whole plant accumulation	[illegible]	[illegible]	[illegible]	[illegible]
Percent grain		[illegible]	[illegible]	[illegible]
# of plants			1.00	[illegible]
K Treatment				1.00

*NS = Not significant at [illegible]

Table B-8 Correlation coefficients for sorghum grain mineral concentration at location 1

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	CH	IVOMD	TRT
N	1.00	0.47	NS[a]	-0.46	NS	0.57	NS	NS	NS	NS	NS	0.84
P		1.00	NS	NS	0.44	0.44	NS	0.46	NS	NS	NS	0.48
K			1.00	NS	0.65	NS	NS	NS	0.46	-0.60	NS	0.76
Ca				1.00	NS	-0.40	NS	NS	NS	NS	NS	0.41
Mg					1.00	NS	NS	0.41	0.80	-0.71	NS	0.40
Fe						1.00	NS	NS	NS	NS	NS	NS
Mn							1.00	NS	NS	NS	NS	NS
Cu								1.00	0.51	NS	NS	NS
Zn									1.00	0.57	NS	NS
CH										1.00	NS	NS
IVOMD											1.00	NS
TRT												1.00

[a] NS = Not significant at the 0.05 level of probability

Table J-[illegible]. Correlation coefficients for sorghum [illegible]

	N	P	K	Ca	Mg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	NS*	NS	NS	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.31	NS	NS	0.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NS	NS
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NS	NS
Fe						[illegible]	[illegible]	[illegible]	[illegible]	NS	NS	NS
Si							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]								1.00	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									[illegible]	[illegible]	[illegible]	[illegible]
OM										1.00	[illegible]	[illegible]
IVOMD											1.00	[illegible]
TRT												[illegible]

*NS = not significant at the 0.05 level of probability.

[illegible] coefficients for sorghum gr[illegible]

	N	P	K	Ca	Mg	Fe	Mn	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	NS[a]	NS	NS	NS	0.45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.88	0.40	0.93	0.38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	0.80	0.87	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	0.61	NS	[illegible]	[illegible]	[illegible]	-0.56	NS
Mg					1.00	0.35	[illegible]	[illegible]	0.69	0.95	[illegible]
Fe						1.00	0.35	[illegible]	[illegible]	NS	[illegible]
Mn							1.00	[illegible]	0.68	[illegible]	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]
DM										[illegible]	[illegible]
[illegible]											[illegible]

[a] NS = Not significant at the 0.05 level of probabil[illegible]

Table 8.11 Correlation coefficients fo [illegible]

	N	P	K	Ca	Mg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	NS*	NS	0.48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	NS	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	NS	NS	NS	[illegible]	0.56	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	0.68	0.41	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	0.45	NS	NS	NS	[illegible]	[illegible]	[illegible]
Fe						1.00	NS	0.41	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]	[illegible]
OM										[illegible]	[illegible]	[illegible]
IVOMD											[illegible]	[illegible]
TRT												[illegible]

*NS = Not significant at the 0.05 level [illegible]

Table 8-12 Correlation coefficients for grain [illegible]

	N	P	K	Ca	Mg	Fe	[illegible]	[illegible]	[illegible]	OM	IVOMD	[illegible]
N	1.00	NS[a]	0.53	NS	NS	0.57	NS	[illegible]	[illegible]	NS	[illegible]	[illegible]
P		1.00	NS	NS	NS	NS	NS	NS	0.55	NS	[illegible]	[illegible]
K			1.00	NS	NS	-0.39	NS	NS	NS	NS	NS	[illegible]
Ca				1.00	0.36	NS	NS	NS	0.43	NS	NS	[illegible]
Mg					1.00	-0.39	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]	[illegible]
Zn									1.00	[illegible]	[illegible]	[illegible]
OM										1.00	NS	[illegible]
IVOMD											1.00	[illegible]
IRT												1.00

[a] NS = Not significant at the 0.05 level of probability

[illegible]

	[illegible]	P	K	Ca	Mg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	NS[a]	NS	0.37	0.5[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	NS	-0.59	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	NS	NS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	NS	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	NS	NS	NS	[illegible]
Cu								1.00	NS	NS	[illegible]
Zn									1.00	[illegible]	[illegible]
Oil										1.00	[illegible]
TKT											1.00

[a] NS = Not significant at the 0.05 level of probability.

[illegible]

	N	[illegible]	[illegible]	[illegible]	Mg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.00	0.87	0.85	0.65	0.83	0.54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.84	0.60	0.83	0.82	[illegible]	0.86	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	0.78	0.90	0.68	0.59	0.83	[illegible]	[illegible]	[illegible]	[illegible]
Ca				1.00	0.61	0.47	0.51	0.69	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	0.79	0.67	0.86	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	0.67	0.84	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	[illegible]	0.56	0.80	0.81	[illegible]
Cu								1.00	0.85	0.83	[illegible]	[illegible]
Zn									1.00	0.80	[illegible]	[illegible]
OM										1.00	[illegible]	[illegible]
IVOMD											[illegible]	[illegible]
TRT												[illegible]

Table [illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	0.86	[illegible]	0.96	0.32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	0.91	0.76	0.90	[illegible]	[illegible]	[illegible]	[illegible]	0.91	[illegible]	[illegible]
K			1.00	0.89	0.98	[illegible]	[illegible]	[illegible]	[illegible]	0.17	[illegible]	[illegible]
Ca				1.00	0.32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	0.85	0.84	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	0.84	[illegible]	0.91	0.91	[illegible]
Cu								1.00	[illegible]	[illegible]	0.91	[illegible]
Zn									[illegible]	[illegible]	[illegible]	[illegible]
OM										[illegible]	[illegible]	[illegible]
[illegible]											[illegible]	[illegible]
[illegible]												[illegible]

Table [illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	[illegible]	0.95	0.86	[illegible]
Cu								1.00	[illegible]	[illegible]	[illegible]
Zn									1.00	[illegible]	[illegible]
OM										1.00	[illegible]
TN											[illegible]

Table B-17 Correlation coefficient [illegible]

	N	P	K	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P		1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K			1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ca				[illegible]	0.74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg					1.00	0.87	[illegible]	[illegible]	[illegible]	0.96	0.93	[illegible]
Fe						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zn									[illegible]	[illegible]	[illegible]	[illegible]
OM										[illegible]	[illegible]	[illegible]
IVOMD											[illegible]	[illegible]
TRT												[illegible]

[illegible]

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	DM	IVOMD	TRI
N	1.0	0.[illegible]	0.93	0.80	0.71	NS*	0.67	0.82	0.64	0.81	0.79	0.89
P		1.00	0.85	0.82	0.86	0.53	0.77	0.81	0.89	0.90	0.92	0.76
K			1.00	0.83	0.80	0.54	0.88	0.83	0.82	0.94	0.92	[illegible]
Ca				1.00	0.90	0.48	0.76	0.81	0.68	0.92	0.90	[illegible]
Mg					1.00	0.56	0.65	0.78	0.71	[illegible]	[illegible]	[illegible]
Fe						1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mn							1.00	0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cu								1.00	0.75	0.86	0.89	[illegible]
Zn									1.00	0.87	0.84	[illegible]
DM										1.00	[illegible]	[illegible]
IVOMD											1.00	[illegible]
TRI												[illegible]

*[illegible]

Table 8.19 Correlation coefficients for grain sorghum stalk mineral content at location 3

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	OM	TRT
N	1.00	0.56	0.41	0.62	0.68	0.65	0.48	0.78	0.48	0.54	0.91
P		1.00	0.63	0.54	0.72	0.55	0.66	0.76	0.83	0.65	0.44
K			1.00	0.87	0.88	0.80	0.89	0.81	0.78	0.96	0.52
Ca				1.00	0.93	0.86	0.83	0.83	0.63	0.93	0.73
Mg					1.00	0.83	0.83	0.90	0.79	0.94	0.71
Fe						1.00	0.83	0.77	0.68	0.89	0.70
Mn							1.00	0.79	0.76	0.92	0.56
Cu								1.00	0.79	0.84	0.78
Zn									1.00	0.80	0.46
OM										1.00	0.63
TRT											1.00

APPENDIX [illegible]
YIELD AND CHEMICAL COMPOSITION OF [illegible]
AS INFLUENCED BY NITROGEN [illegible]
AND APPLICATION [illegible]

Table C-1. Soil test results following bahiagrass comparing nitrogen rates, sources, and application methods at three locations

N Rate	Depth	N Source	P	K	Ca	Mg	Fe	Mn	Cu	Zn	pH
kg ha^{-1}	cm		------	------	------	------	mg kg^{-1}	------	------	------	------
			Location 1								
0	0 20	NH_3	30	29	283	64	11	5	08	29	6.4
56			28	27	287	63	11	5	08	23	6.2
112			33	29	32[illegible]	69	13	5	08	35	6.2
168			34	31	320	61	13	5	09	30	6.3
224			34	27	373	73	14	6	13	41	6.5
0		NH_4NO_3	45	29	468	87	13	6	09	37	6.5
56			28	29	333	63	11	5	08	30	6.2
112			29	23	335	71	12	5	07	34	6.1
168			27	21	298	60	11	5	09	28	6.2
224			33	27	344	67	11	5	09	.39	6.7
0	20-40	NH_3	22	19	289	63	11	5	09	11	6.2
56			14	18	120	27	13	3	.07	.13	6.0
112			17	15	756	21	15	2	05	17	5.9
168			16	17	93	23	15	2	07	13	5.7
224			31	12	147	27	16	3	07	11	6.1
0		NH_4NO_3	26	13	118	26	17	3	09	11	6.1
56			17	11	90	19	14	2	08	09	5.9
112			15	25	83	17	15	3	08	08	6.0
168			19	13	125	25	14	3	07	09	5.9
224			19	16	112	21	15	2	07	13	6.0

[illegible] (continued)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}	cm					-- mg kg^{-1}						
						Location 2						
0	0-20	NH_3	04	23	23	175	23	13	[illegible]	16	[illegible]	[illegible]
56			04	26	21	228	28	11	3.4	13	1.03	[illegible]
112			04	20	27	177	26	12	3.0	21	1.29	[illegible]
168			.05	22	25	182	23	12	3.4	15	.87	[illegible]
224			05	22	25	251	[illegible]	11	3.9	16	1.10	[illegible]
0		NH_4NO_3	04	24	25	183	25	12	2.9	18	[illegible]	[illegible]
56			.04	17	25	171	[illegible]	11	2.4	18	[illegible]	[illegible]
112			05	17	25	180	27	[illegible]	3.0	21	1.34	[illegible]
168			05	21	24	171	25	11	[illegible]	21	1.18	[illegible]
224			04	22	[illegible]	[illegible]	[illegible]	[illegible]	3.6	8	1.32	[illegible]
0	20-40	NH_3	02	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13	[illegible]	[illegible]
56			02	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112			02	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168			.02	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224			02	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0		NH_4NO_3	03	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
56			03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112			03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168			03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224			03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]— Continued

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
$(g\ m^{-2})$	[illegible]										
			[illegible]								
0	[illegible]	NH_3	[illegible]	[illegible]	119	32	[illegible]		[illegible]	[illegible]	[illegible]
56			[illegible]	[illegible]	190	33	[illegible]		[illegible]	[illegible]	[illegible]
11[illegible]			[illegible]	[illegible]	151	27	[illegible]		[illegible]	[illegible]	[illegible]
168			[illegible]	[illegible]	97	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
0		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
56			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
11[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	[illegible]	NH_3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
56			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
224			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Nitrogen rate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg ha^{-1}			[illegible]		
		[illegible]			
0	[illegible]	330	[illegible]	[illegible]	[illegible]
56	[illegible]	1280	[illegible]	[illegible]	[illegible]
112	[illegible]	1530	[illegible]	[illegible]	[illegible]
168	[illegible]	1280	[illegible]	[illegible]	[illegible]
224	[illegible]	1300	[illegible]	[illegible]	330
LSD 0.05	[illegible]	[illegible]	[illegible]	[illegible]	NS*
		[illegible]			
[illegible]	[illegible]	610	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1050	[illegible]	[illegible]	—
112	[illegible]	1180	[illegible]	660	—
[illegible]	[illegible]	1460	[illegible]	830	—
[illegible]	[illegible]	1400	[illegible]	900	—
LSD 0.05	[illegible]	210	[illegible]	180	
		Location 3			
0	490	510	420	380	280
56	820	890	750	600	330
112	750	950	840	650	300
168	740	1150	1040	880	420
224	850	1470	1300	1100	520
LSD 0.05	230	270	300	220	130

*NS Not significant at the 0.05 level of probability

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy

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